Horticulture and Crop Science Department Series 712 July 2001

2001 Ohio Grape-Wine Short Course

"The Path to Gold"

Edited by Todd Steiner

Sponsored by Horticulture and Crop Science, The Ohio State University

In cooperation with

Ohio Agricultural Research and Development Center
Ohio Cooperative Extension Service
Ohio Grape Industries Committee
Ohio Wine Producers Association

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Horticulture & Crop Science Series 712 June 2001

Proceedings of the

OHIO GRAPE-WINE

SHORT COURSE

February 18-20, 2001

Edited by

Todd Steiner, James Gallander and Dave Ferree

Sponsored by
Department of Horticulture and Crop Science
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With contribution from
Bonnie Franks
Dave Scurlock
Ken Chamberlain
Jesse Ewing

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PREFACE

More than 165 people attended the 2001 Ohio Grape-Wine Short Course, which was held at the Wyndham Dublin Hotel in Dublin, Ohio on February 18-20, 2001. A record banquet attendance witnessed the initiates of the Ohio Wine Hall of Fame, with the first inductees being Nicholas Longworth, Robert Gottesman, James Gallander and Garth Cahoon. The short course was sponsored cooperatively by the Department of Horticulture and Crop Science, The Ohio State University, Ohio Agricultural Research and Development Center, Ohio Wine Producer's Association and Ohio Grape Industries Committee.

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CHEMICAL DEACIDIFICATION OF MUSTS AND WINES

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Acidity is one of the major components of wine flavor. It gives wine freshness, tartness and crisp taste. A certain amount of acidity is essential to produce a well balanced wine. In wine production, balancing the flavors is an important concept that a winemaker should know. For example, in a dry white wine the tannin level is usually low so the sweet taste of alcohol is balanced with an appropriate amount of acidity. Depending on alcohol level, high acid wine can taste hard and firm while low acid wine tastes mellow, flat or insipid (Peynaud, 1987). In sweet white wine, the sweet taste of alcohol and sugar requires a higher acid level to obtain the proper balance.

Red wine contains tannins in addition to alcohol and the acids. The tannins contribute to bitterness and astringency. In red wine the sweet taste of alcohol is counter balanced with acidity plus the astringency. Acidity enhances the perception of bitterness and astringency, therefore, appropriate amount of acids in red wine should be based on tannin and alcohol level. It should be clear that a less tannic wine can support a higher acid level (needed for freshness as in blush and rose wines) than a more tannic wine. Highly tannic wines with pronounced acidity tastes hard and astringent (Peynaud, 1987). The balance of major taste components is further shown below.

Dry white	Sweetness	→	Acidity (Tartness)
	(alcohol)	←	
Sweet white	Sweetness	←	Acidity
	(Alcohol + sugar)	→	
Red wine	Sweetness	→	Acidity + Astringency + Bitterness
	(Alcohol)	←	(Tannins)

Besides being a major taste constituent, acids also play another important role in wine.

Their dissociation generates H ions and these H ions constitute wine pH. The pH is a very important quality parameter of a wine. It influences microbial growth, oxidation reactions, bitartrate and protein stability, effectiveness of sulfur dioxide and sorbic acid (when used), pigment ionization and wine color (red wine), and in some situations on sensory (bitterness and astringency) properties of wine.

When determining the appropriate level of acids in wine, or making acid adjustments, it is not enough to consider the influence of acids on taste but is equally important to assess their impact on wine pH.

The acidity in wine is due to several organic acids derived from grapes and those produced during fermentation. Tartaric, malic and citric acids are produced in grapes. Succinic, lactic and acetic acids are formed during fermentation. During ripening the acid contents of the grapes decrease and the pH rises. The reduction in acidity and subsequent increase in pH is mainly due to degradation of malic acid (specially more in hot climate) and the neutralization of acids by the incoming cations, mostly potassium. The decision to harvest the fruit is made when acidity, pH and sugar reach a desired level.

In some cases the grapes contain excess acidity at harvest. This condition usually occurs in grapes grown in cool climates or in a short growing season where fruit does not have sufficient time to ripen properly. When faced with this high acid problem a winemaker needs to reduce acidity in order to make balanced wines. Several methods can be used to reduce acidity in must and wine. These include:

- Amelioration
- Blending with low acid must/wine
- Malolactic fermentation
- Acid reducing yeast strain
- Ion exchange
- Chemical deacidification

Chemical deacidification is the focus of this presentation. In order to understand deacidification reactions a brief review of wine acids and their chemical properties is helpful.

Grape and wine acids

Important acids of grapes and wine along with their molecular structure, molecular weight, equivalent weight and pKa values are listed in table given below.

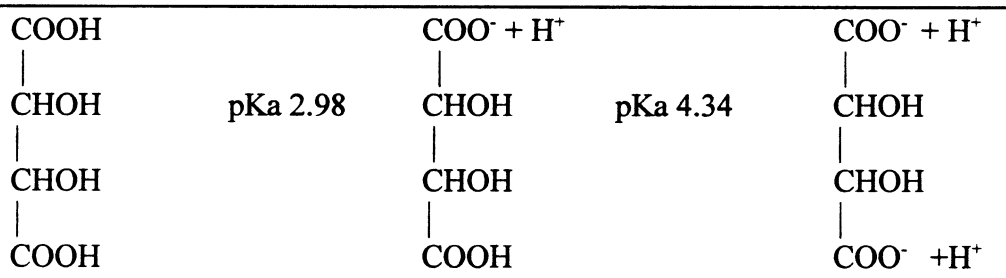
Acid	Molecular structure	Molecular weight	Equivalent weight	pKa1	pKa2
Tartaric	COOH-(CHOH)2-COOH	150.1	75	3.04	4.34
Malic	COOH-CH_2-CHOH-COOH	134.1	67	3.46	5.1
Citric	CH_2COOH-CHOCOOH-CH_2COOH	192.1	64	3.13	4.74
Lactic	COOH-CHOH-CH_3	90.1	90	3.86	-
Succinic	CH_2-COOH-CH_2-COOH	118.1	59	4.21	5.64
Acetic	CH_3-COOH	60.1	60	4.75	-

pKa values at 25 °C Source: Adapted from Margalit (1997)

The principal acids of grape and wine are tartaric and malic and they often account for over 90% of the acids found in grapes.

Tartaric acid

Tartaric acid is the main acid found in grapes and wine. Concentration of tartaric acid in grapes ranges from 2 to 10 g/l (Zoecklein et al, 1995). At wine pH it is biologically stable. With potassium it forms an acid salt known as potassium bitartrate and with calcium it forms calcium tartrate. Potassium bitartrate and calcium tartrate are poorly soluble in wine and cause instability problems. Tartaric acid is a weak di-carboxylic acid and in juice and wine it exist as free acid and bitartrate and tartrate ion. The dissociation of tartaric acid is shown below.

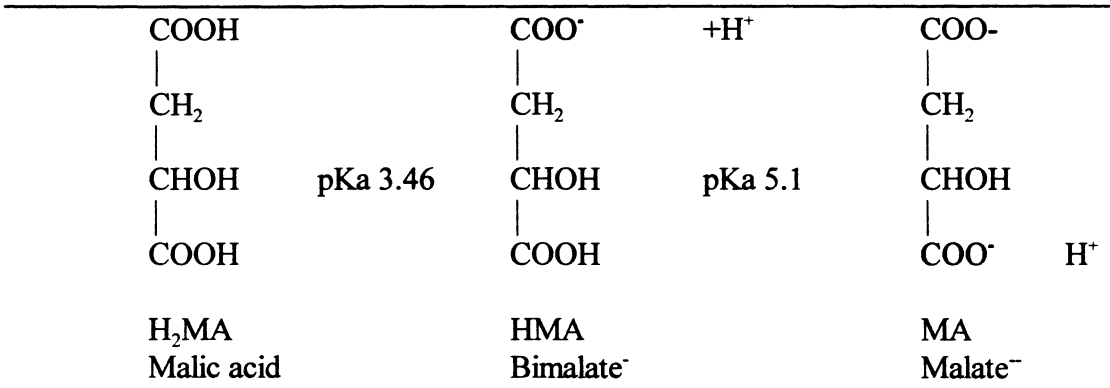


H_2T Tartaric acid | HT^- Bitartrate | HT^- Tartrate

Note: pKa's are pH values at which the adjacent spices are in equal concentration.

Malic acid

Malic acid is another important acid found in grapes. It is also widely distributed among many other fruits. Its concentration in berries varies according to variety, climate (particularly the temperature during ripening), fruit maturity and viticulture practices. Generally the amount ranges between 2 to 4 g/L, but higher levels as much as >7.0 g/L have been reported (Dharmadhikari and Wilker, 1998). The acid can be degraded by yeast and lactic acid bacteria. With calcium it forms calcium malate which is also poorly soluble and can partially precipitate during double salt deacidification treatment. Like tartaric acid it is also a di-carboxylic acid but it is weaker than tartaric. Its dissociation is shown below.



Note the higher pKa value which indicates that malic acid does not dissociate as strongly as tartaric acid. Being a weaker acid, for the same concentration malic acid gives a higher pH than tartaric acid.

Titratable acidity (TA)

Titratable acidity is a measure of the number of H^+ ions found by titration of juice or wine with a standard base at pH of 8.2 (in USA). It is commonly expressed in terms of tartaric acid equivalent. During titration both the un-dissociated and dissociated protons are recovered.

pH

The pH is a measure of H^+ ion concentration in a solution. It indicates the number of free hydrogen ion that are in ionization equilibrium with organic acids (Boulton, 2001). It is determined by using a pH meter. The must /wine pH generally ranges between 3.0 and 4.0, but pH values in the range of 3.2 to 3.6 are more common.

Acidity conditions

Acidity and pH conditions can be classified as follows (Boulton, 1984).

	TA	pH
Low TA and high pH	< 6g/L	> 3.5
Moderate TA and pH	6 to 9g/L	3.0 to 3.5
High TA low pH	> 9g/L	< 3.0
High TA and high pH	> 9g/L	> 3.5

Low TA and high pH generally occurs in hot climates and would require acid addition. In moderate TA and pH condition small adjustments (up or down) in TA and pH can be made in several ways if needed.

High acid, low pH situation can be variety dependent but is usually observed in cooler climates or in unripe fruit. Chemical deacidification treatment can be employed to lower the acidity of must/wine. However, the choice of material used needs to be carefully evaluated. For a slight acid reduction (TA 8-10g/L), in a low pH (pH<3.0) wine, carbonate or bicarbonate of potassium can be used. With this compound there is no risk of calcium instability. In a highly acidic must/wine (TA>10g/L) calcium carbonate as a single salt or more preferably as a double salt should be considered for acid reduction. High TA and high pH is a problematic situation, which results from high acid and high potassium (also high calcium) content. This condition will need Acidex treatment along with tartaric addition to lower acidity and pH.

Chemical deacidification

Chemical deacidification involves treatment of wine with a basic compound to neutralize the acids. The choice of compound for deacidification depends on several factors such as:

- Initial TA and pH of must/wine
- Extent of acid reduction desired
- Target TA and pH values
- Acid composition of must/wine
- Buffer capacity
- Treatment effect on wine stability
- Effect on organoleptic properties of wine

Using carbonates

The compounds authorized in USA for acid reduction include potassium carbonate and bicarbonate, calcium carbonate and Acidex. The treatment with carbonate salts results in neutralization of acid and precipitation of acid-salt or salt. There are two components to this reaction:

- The anion reaction
- Cation reaction

The anion reaction leads to the formation of carbonic acid as an intermediate product and finally CO_2 and water.

$CO_3^{=} + H^+$	→	$HCO_3^- + H^+$	→	H_2CO_3	→	H_2O	+	CO_2
Carbonate anion		bicarbonate anion		carbonic acid		water		carbon dioxide

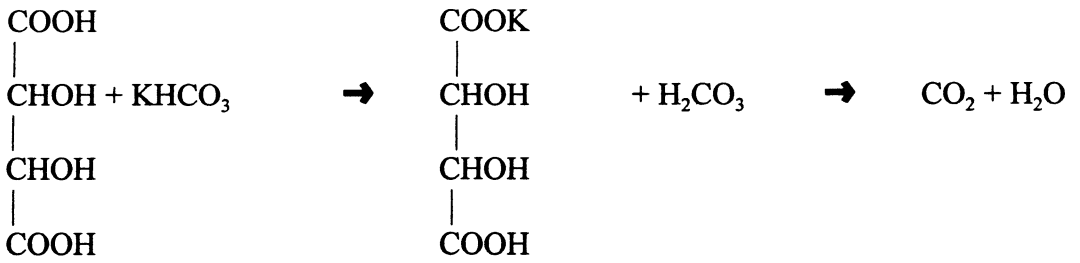
In treatment with carbonates the anion reaction is the same (CO_2 + water). The cation reaction is different and produces acid-salt or salt. The reaction is shown below.

$HT^- + K^+$	→	KHT (potassium bitartrate) acid-salt
$T^{=} + Ca^{++}$	→	CaT (calcium tartrate) single salt
$T^{=} + Ma^{=} + Ca^{++}$	→	Ca_2TMa (calcium tartrate-malate double salt)

Addition of carbonates neutralizes acids and as a result the pH increases.
For sound enological reasons the wine pH should not be allowed to rise above 3.5 or 3.6, although this is not always practical.

Potassium carbonate and bicarbonate

Either one of these compounds can be used to reduce the acidity. However Mattick (1984) recommended using potassium bicarbonate because it is a weaker base. The acid reduction occurs due to the neutralization and the precipitation of the acid-salt. The reaction is shown below.



Note that neutralization has produced an acid salt and only one proton has been removed, the other acid proton is still present in the carboxyl (COOH) group in the acid salt. Precipitation of the potassium bitartrate (acid-salt) will result in the loss of second proton and thus further reduction in acidity. According to Boulton et al (1996) the precipitation of potassium bitartrate will result in a loss of 1g/L of TA for each 2.51g/L of the salt formed.

Depending upon wine pH, potassium bitartrate precipitation can result in lowering or raising the pH. The critical pH value below which the acid salt precipitation causes reduction in pH has often been mentioned to be 3.65. This value applies to water solution containing only tartaric acid. In wine, due to the ethanol and ion content, the value is claimed to be higher, more like 4.1. (Boulton et al, 1996). Above this (4.1) pH, precipitation will show an increase in pH. From a practical point of view, one would not want to make wine with such a high pH value. The maximum pH acceptable would rarely be above 3.7. Under this high pH scenario a reduction in pH (although small) would be realized following potassium bitartrate precipitation.

Mattick (1984) suggested that a wine with a TA of 8 to 10g/L can be safely deacidified with potassium carbonate or bicarbonate and adding 0.62g/L potassium carbonate or 0.9g/L of potassium bicarbonate will reduce TA by 1.0g/L.

Calcium carbonate

Calcium carbonate is commonly used to lower acidity in high acid must/wine. The reaction primarily produces calcium tartrate (a neutral salt) which precipitates over time. The reaction is shown below.

The precipitation of calcium salt occurs slowly and can not be speeded up by chilling the wine like the potassium bitartrate. Note that calcium carbonate is a neutral salt (as opposed to potassium bitartrate which is an acid salt) and its precipitation will not cause acid reduction. As compared to potassium carbonate, deacidification with calcium carbonate gives maximum acid reduction with minimal increase in pH (Nagel et al, 1975 and Munyon and Nagel, 1977).

Therefore, in a very high acid must/wine, calcium carbonate can be effectively used to reduce acidity without raising pH to unacceptable level. Theoretically, the addition of 0.67g/L of calcium carbonate will reduce TA by 0.1%.

Either must or wine can be deacidified with calcium carbonate however, must treatment does pose few problems. In the case of red must, due to the presence of skins and seeds, it is difficult to accurately measure the volume and therefore the amount of calcium carbonate needed for the treatment. Consequently it is difficult to obtain precise acid reduction with the must treatment.. When dealing with white must the treatment is easy to administer. However, potassium ions in the juice can interfere with the calcium carbonate reaction and thus produce insufficient deacidification. (Nagel et al, 1975). Lowering acidity will raise pH and a fermenting must at high pH can adversely affect the sensory quality of the wine. For the reasons mentioned above deacidification of wine appears more practical.

Calcium carbonate "double salt"

There are some disadvantages in using calcium carbonate for acid removal. Delayed precipitation of calcium tartrate has already been mentioned. Another is the high calcium content in the resulting wine, which can cause calcium instability and also contribute to the chalky taste of wine. The high calcium content is attributed not only to slow precipitation of calcium tartrate but also to the more soluble calcium malate, which can remain in wine. The calcium malate can be a bigger problem in wines with higher malic acid content (cool climate).
In order to speed up precipitation and removal of calcium tartrate and calcium malate, calcium carbonate treatment in a "double salt" manner has been developed. The double salt application is also called Acidex procedure and was developed in Germany. Acidex is a proprietary name for a compound containing finely ground calcium carbonate and about 1% calcium tartrate-malate double salt crystals. The seed crystals encourage nucleation and crystal growth and thus promote precipitation of double salt.

Acidex treatment

According to this procedure a portion of the must/wine to be treated (about 10%) is added to the acidex powder and stirred, forming a suspension or slurry. To this slurry the remainder (90%) of the must/wine is slowly added while mixing vigorously. Because the acidex is added only to a portion of the must/wine, the concentration of calcium in the slurry becomes very high, and the pH of the mixture rises as high as 6.5 (and later drops to 4.0 to 4.5). The addition of must/wine is done slowly to maintain pH above 5.0 during the operation. This step is important because at pH 5.0 or higher, tartaric and malic acid mostly exist in tartrate ($T^{=}$) and ($Ma^{=}$) forms. These conditions favor formation and precipitation of calcium salt of tartaric and malic acid. As a result concentration of both acids and the calcium is lowered. The precipitated material is removed by filtration and the must/wine is blended back with the untreated portion.

Information regarding the amount of acidex required for acid reduction and the volume of

must/wine needed for treatment can be obtained from the supplier. Generally about 0.7g/L of acidex is needed to reduce acidity by 1g/L (.1%). The volume of the treated portion depends on initial and target acidity but generally it in the range of 35 to 50 %.

In a double salt precipitation one would expect removal of tartaric and malic acid in equal amounts. But the evidence has shown that more tartaric than malic is removed. (Munyon and Nagel, 1977 and Steele and Kunkee, 1978). It appears that the precipitate primarily consists of calcium tartrate and some calcium malate. Removal of both acids in equal amounts was shown to occur when the initial concentration of malic acid was twice the amount of tartaric. (Murtaugh, 1990).

Deacidifying wine with calcium carbonate involves certain risk of Ca instability. Therefore, a winemaker should make sure that a wine is stable with respect to CaT before bottling.

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MICROBIOLOGICAL TESTING FOR WINERY SANITATION

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Purdue University

Whether or not you like to admit it, if you are dependent on controlling the behavior of yeasts to make your living, you are a microbiologist. Fortunately most of the microbes encountered in a winery are involved in performing desired services such as making alcohol out of sugar, and turning malic acid into lactic acid. The encouragement and manipulation of these elite microbes is detailed in the literature distributed with commercial cultures and is generally well known to winemakers. However, enologists are also constantly harassed by microscopic villains, and this presentation is designed to give you some insight in dealing with their detection, identification and control. Although lack of equipment and familiarity with techniques may limit your range, many important microbial matters can be properly attended to by the layman.

You will need to begin with a clean white lab coat and a few bits of micro trivia to impress your visitors. Try these:

1. Wine yeasts replicate mainly by a process called budding, which, under optimum conditions, may result in doubling the population every two hours. Therefore, a single, lonely yeast may create a world of more than 16 million relatives in one wild weekend.

2. Wine may appear visibly clear while hosting a party of 100,000 bacteria or 10,000 yeasts in every milliliter. That is 50,000 yeast cells in a teaspoon of wine.

3. One gram of dry yeast contains 10 billion living yeast cells. Think about that next time the can tips over in your refrigerator.

4. No infectious microorganism, whether yeast, bacteria or even virus, can grow or even survive very long in the hostile environment of wine.

WHY SANITATION?

Since microorganisms cannot survive in wine, and food poisoning is not an issue, why do wineries need to concern themselves with the tedious and time-consuming processes involved in winery sanitation? Many reasons come to mind:

- Refuse attracts vermin and insects
- Neglected contamination is more difficult to clean when it has dried and adhered to surfaces, decreasing plant efficiency
- Contamination causes deterioration of plastic, rubber, metal and wood surfaces
- Aesthetic considerations for visitors
- Potential for wine spoilage

A WORKPLACE

The ideal place for your microbiological activities would be a small room, bathroom size, with washable walls, ceiling and floor, and containing a small sink and formica table top. Put a sign on the door limiting use and access to certified microbiologists (wearing white coats) only.

Second choice would be a corner of a multipurpose room, away from the fermentation area, which could be isolated from visitors, workers and outside air currents when micro work is in progress.

A third, and very weak choice, would be a corner of the winery.

When microbiological tasks must be performed in a multipurpose area, a small-contained workplace called a hood, which can be sanitized and will protect the work area from dust and air currents, is necessary. If you purchase used equipment avoid chemical hoods, as they are designed for rapid air circulation in the wrong direction for micro work and are impossible to sanitize. Plans for building a small effective hood are illustrated in Figure 1. This unit, made of ½-inch plywood, 1/4 inch Plexiglas and a few hinges, costs less than $50 to build. The plywood back and adjoining sides are cut on a bevel and hinged together to collapse for storage. The Plexiglas panels, which give the user visibility, while deflecting dust and breath aerosols, are slid into grooves made by 1/4-inch chair railing strips. The unit is covered with several coats of white, high gloss, appliance enamel paint.

A small Styrofoam incubator (Fig. 2) will provide a continuous temperature to grow yeasts and bacteria rapidly. The temperature is controlled by the wattage of the light bulb used in a socket assembly, which has been inserted through the side of the Styrofoam ice chest. This unit maintained a constant temperature of 75° F with a 5-watt bulb and cost less than $10 to assemble.

Sanitation of the workspace should be done before and after each use. A solution containing 100 ppm available chlorine , about 8 mls or 1 ½ teaspoons of laundry bleach in 1 gallon water, will effectively sterilize the work surfaces.

The following list contains most of the equipment needed to collect if you plan to set up a small effective micro laboratory. A source, catalog number and approximate price for all items are listed; however, in most cases they are available from many different suppliers who will be glad to cross reference catalog numbers. Sources listed here are based mainly on price and availability.

EQUIPMENT:

1. **Hood -** specifications listed below

2. **Incubator -** specifications listed below

3. **Aspirator Filter Pump - Nalgene.** Fisher Scientific, Cat. # 09-960-2, $5.
Produces vacuum needed to pull wine samples through filter assembly.

4. **Alcohol Burner - glass lamp.** Fisher Cat # 04-245 AA, $4.
Used to burn off alcohol on disinfected equipment, dry microscope slides, sterilize loop, etc.

5. **Side Arm Vacuum Flask - 1000 ml Nalgene.** Fisher Cat. # 10-f182-50B, $11.
Supports filtration unit for sterility evaluation of wine and juice.

6. **Rubber Stopper, size 8, one hole.** Fisher Cat. # 14-135M, pkg 12/$12.
Connects filtration unit to vacuum flask.

7. **Vacuum Tubing, black rubber.** Fisher Cat. # 14-175D, pkg. 12 ft/$35.
Connects vacuum flask to sink aspirator.

8. **Millipore Yeast & Mold Swab Test Kits.** Millipore Cat. # MYSK 1OO 25, 25 tests/$109.
Used to evaluate microbial contamination of winery equipment, corks, etc.

9. **Millipore 55 Plus Monitor.** Millipore Cat. #MHWG 05500, pkg 50/$81.
For analysis of yeast, mold and bacterial contamination of juice and wine.

10. **Millipore Media in 2 ml plastic ampules:**
Added to 55 PLUS filter monitor after sample filtration to provide nutrient for microbial growth.

    Tomato Juice Broth, Cat. # MXOOTJ220, pkg 20 ampules/$26
    Best for lactic acid bacteria, also yeast and mold.
    WL Nutrient Broth, Cat. # MOOOOOP2N, pkg 20 ampules/$26
    Yeast, mold and bacteria.
    WL Differential Broth, Cat. # MXOOWD220, pkg 20 ampules/$26
    Contains cyclohexamide to inhibit yeast growth, except Brettanomyces.

11. **Paper Chromatography Kit.** Presque Isle Wine Cellars Cat. # PCK-2V, #31.
Detects malolactic fermentation in wine.

12. **Methylene Blue.** Fisher Cat. # M281-25, 25 gms/ $25.
Dissolve one gram Methylene blue powder in 10 mls alcohol, add 90 mls water. Use to stain yeast and bacteria for microscopic observation.

13. **Alcohol, denatured ethanol or isopropanol.** Drug store item.
70% solution in water good disinfectant for surfaces that will come in contact with wine. Denatured is fine for culture work, use food grade for corker jaws, filler spouts.

14. **Sterile Whirl Pack Bags - 180 ml.** Fisher Cat. # 01-812-5A, pkg 500/$36.
Sterile, disposable plastic bags for sample collection from tanks, barrels, etc.

15. **Microscope, glass slides and coverslips, inoculating loop.**

SUPPLIERS:

MILLIPORE, PO BOX 255, BEDFORD, MA 01730 (800)645-5476
VINQUIRY, 16003 HEALDSBURG AVE., HEALDSBURG, CA 95448 (707)433-8869
THE WINE LAB, 477 WALNUT ST. NAPA, CA 94559 (707)224-7903
PRESQUE ISLE WINE CELLARS,9440 BUFFALO RD, NORTH EAST, PA 16428
(814)725-1314

The purchase of a microscope is not within every winery's budget; however, if you do not have access to a university or medical laboratory with a good microscope to help you evaluate wine sediment problems and identify microbes, there are several sources of used microscopes. If you are fortunate enough to find a reasonably priced used microscope in good condition with built in illuminator and oil immersion (1000X) capabilities, and you can have someone test it to be sure it is working well, buy it. Many universities sell surplus microscopes, which have become obsolete, but are more than satisfactory for these purposes. Although phase contrast microscopy is often discussed and can be helpful, the microscope is very expensive and requires a thorough knowledge of microbes to differentiate them from debris in the sample. The internet is another good source; however, be sure you are buying from a reputable source and that it is guaranteed at least until you can check the instrument out.

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(814)725-1314
FISHER SCIENTIFIC, 1600 W. GLENLAKE AVE. ITASCA, IL 60143 (800)766-7000

Sanitation of the workspace should be done before and after each use. A solution containing 100 ppm available chlorine , about 8 mls or 1 ½ teaspoons of laundry bleach in 1 gallon water, will effectively sterilize the work surfaces.

THE HUMAN DIRT DETECTOR

For evaluating the effects of winery sanitation procedures, one should begin with a careful visual and olfactory examination of the area, keeping in mind that one who lives by the sniff test may die by the sniff test. If you see dirt, cork particles, old dried mold residue in tubing, grape skins in the drain, sticky juice on filter drip trays, insects or vermin, or if you smell off odors in tubing, carboys, barrels, trash cans, the area is not sanitary, no matter how much spraying of disinfectant may have been done. If your area passes an eye and nose inspection, then it's time for a microbial culture.

MICROBIOLOGICAL EVALUATION OF WINERY SANITATION

The Millipore Company produces a 'Swab Test Kit' with 'Yeast & Mold Tester', which is effective in determining the population of living yeasts and molds on a surface.

The first step in any microbiological procedure is to eliminate yourself as a source of contamination as much as possible. Putting on a clean lab coat laundered in hot water and Clorox to cover clothing which may be spattered with wine or dirt, controlling long loose hair in a clip, and washing hands with soap, then spraying with 70% alcohol would all be effective. If the directions supplied by Millipore are followed carefully, you will have an accurate estimation of contamination of areas such as tank interiors, valves, corks, filler tubes, etc. The methodology involves rubbing the area in question with the swab, transferring the swab to a buffer solution to suspend any organisms, which have been picked up, then dipping a media impregnated filter membrane into the buffer. The filter membrane is shaken to remove excess buffer, then replaced in its sterile housing and incubated, filter surface down, for 5-7 days at 75° F.

Look for growth after 48 hours, since mold colonies may grow fuzzy and very large - they will obscure the entire filter after a few days making it impossible to evaluate other growth. Each viable organism that lands on the filter will begin to multiply and eventually produce a small drop-like pile called a colony. Counting the number of colonies gives an estimate of how many living organisms were picked up on the swab. The presence of yeast and/or mold contamination indicates bacterial contamination also exists in the area tested, and the absence of yeast or mold growth gives reasonable assurance that the area is also free of bacteria.

In general, yeasts are smooth, shiny or creamy spots, 2-4 mm in diameter, growing in 2-5 days. Molds will begin as very small rough colonies becoming larger and fuzzier with time. They may be green or olive or black if spores form. Most bacteria will not grow on this kit. Occasionally, Bacillus sp. from dirt may grow forming yeast-like colonies, or appear as a slimy, flat, rapidly spreading white or nearly transparent film on the tester membrane. If the results of your swab culture show more than 2-3 colonies of yeast or mold, better sanitation methods would be suggested. If your tester shows no growth in 5-7 days, give your sanitary engineer a raise.

BOTTLE STERILITY EVALUATION

Although there are many different units designed for measuring living or viable organisms in a product, the Millipore 55 PLUS monitor is easy to use and designed to reduce accidental contamination. This system allows you to filter a volume of juice or wine - trapping any yeasts or bacteria on the surface of a filter membrane. When nutrient media is applied to the membrane and the system allowed to incubate at 75° F for 7-10 days, the organisms will grow into colonies, which can be enumerated and identified.

Careful washing of the bottle to be evaluated, and spraying the neck, cork and cork puller with 70% alcohol will eliminate most of the potential for contamination from the exterior of the

bottle. The "Ah-So" type of cork puller with two prongs, used carefully, generally produces fewer cork crumbs than the screw type. Shake the bottle thoroughly just before removing the cork or screw cap and pour 100 ml of wine into the filter unit. If the wine is an unfiltered or very intense red, begin with 25 ml to be sure the entire sample passes through the membrane. Millipore furnishes extensive directions for the use of these units. Sterile water needed to rinse the excess wine (and preservatives such as SO_2 and sorbate) from the membrane may be obtained easily by micro waving a glass bottle with a microwave safe plastic cap half filled with water. Allow the contents of the bottle to come to a boil, then keep it simmering for 1 minutes on low power. As soon as you remove the bottle from the microwave, tighten the cap and allow the contents to cool.

Evaluation of the colonies growing on this filter system is similar to the 'Yeast and Mold Tester' in many ways; however, the WL nutrient medium does allow growth of wine spoilage **bacteria** and gives some color differentiation of the colonies.

In general, if a colony growing on a filter membrane is larger than 7-10mm after 7 days, slimy, fuzzy or exotically colored (red, pink, orange shades), it is not a wine spoilage organism. Since molds will not grow in bottled wines, they are not a concern in this evaluation. The presence of mold colonies or other non-spoilage organisms may indicate poor techniques during wine sampling, in which case several bottles should be selected for re-testing.

Yeasts will produce visible colonies in 3-5 days as described above. Bacteria take 5-10 days, colonies will appear very small, sometimes nearly transparent requiring magnification to identify them. The presence of one or zero colonies on the filter after 10 days gives you a great deal of confidence that your wine is microbiologically stable. Even in a very dry wine, <0.1% sugar, the growth of a few yeast or bacteria colonies suggests that you should hold the wine for a few weeks at ambient temperatures and do another filtration evaluation to see if the population is increasing. If you count more than 10 colonies on the filter, immediate action should be taken before bottle spoilage goes any further.

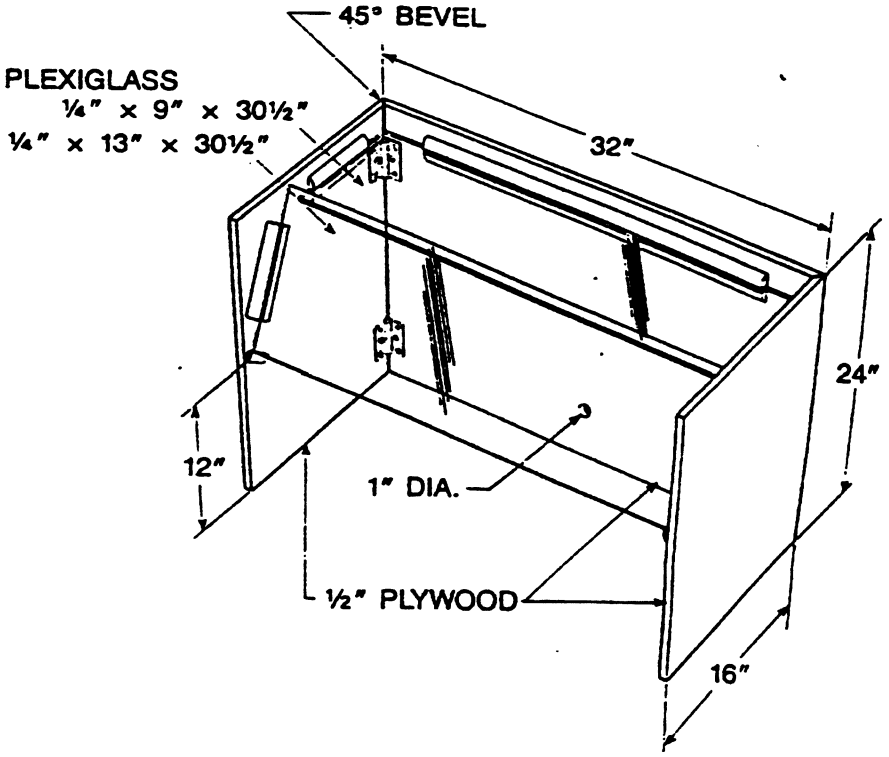
One good system for evaluating a particular bottling would be to sample the first bottle off the line (to determine whether cleaning procedures were adequate), the last bottle (to determine the integrity of the system) and several at regular intervals during the entire run. The middle samples give some idea of extent of the problem.

Commercial laboratories charge $10-20 for this type of analysis, depending on your requirements. The Millipore kits cost about $1.50 per sample and eliminate the need to mail samples.

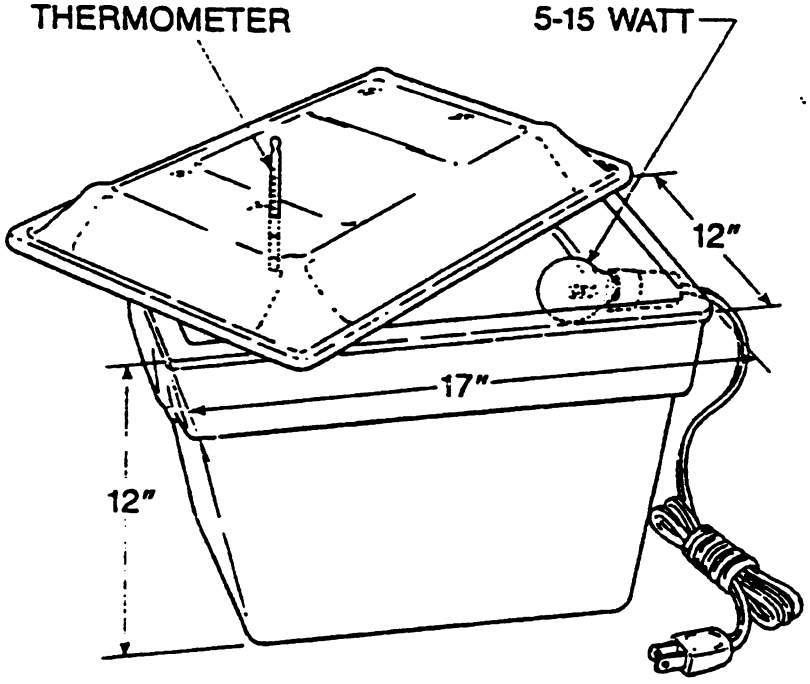
When information gleaned from using these simple microbiological techniques is combined with organoleptic observations and chemical analyses, the causes of most wine spoilage can be determined in the small winery. If more information is needed, wine samples or cultures can be sent to commercial labs or universities with wine research and/or extension facilities for final identification.

Although there are many more techniques which can be acquired to do thorough microbial analyses of winery problems, I hope these tips will help you feel more confident in doing some of your own evaluations and controlling the unwanted microbe activity in and around your winery.

PORTO-HOOD



STYROFOAM INCUBATOR



(WATTAGE of lightbulb determines temperature)

BAD MICROORGANISMS IN WINES

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Most food spoilage microorganisms as well as pathogenic species are of little concern to the winemaker. This is because wine presents a hostile environment to most microorganisms due largely to its low pH, high ethanol content, and the common use of sulfur dioxide as a preservative in winemaking.

This report will deal mainly with the different microbial groups that are capable of spoiling wines. A subsequent paper will show the fate in wine of a serious food borne pathogen, *Escherichia coli* O157:H7.

Potential wine spoilage microorganisms are largely certain yeasts, a few molds, lactic acid bacteria and acetic acid bacteria.

Yeasts

Numbers - We have found that most sound grapes will yield yeast populations ranging from 10^3 to 10^4 per gram. A few samples, however, will have counts in the 100s/gram and a very few will show contamination levels of 10^6 or higher. Most of these "wild" yeasts are species other than *Saccharomyces* and thus most do not compete well with true wine yeasts.

The common practice of treating musts with 50-100 ppm sulfur dioxide eliminates a high percentage of the wild yeasts because most are quite sensitive to this compound (Table 1).

Brettanomyces - In recent years this yeast has been recognized as a spoilage organism of wines. It is unique in that it can produce acetic acid from glucose. It also forms certain tetrahydropyradines that can give wines a characteristic off-odor. Some winemakers, however, believe that a limited amount of "Bret" activity adds complexity to certain wines.

Saccharomyces cerevisiae - These wine yeasts are potential spoilers of bottled wines if the wines are not completely dry, generally if they contain over 2 g/L of fermentable sugar. Control of these yeasts is obtained by the addition of potassium sorbate, by sterile filtration prior to bottling, or by pasteurization.

Molds

These filamentous fungi are usually not a big problem for the winemaker. They require air for their growth, most are inhibited by ethanol, and, in general, molds are quite sensitive to sulfur dioxide. Under certain conditions the mold, *Botrytis cinerea*, enhances the quality of dessert wines such as

sauternes and, as a result, is referred to as noble rot.

Molds will grow on many surfaces, including cooperage, when a high humidity exists. Off-odor taints can result.

Most of the molds that are associated with wines do not produce mycotoxins although a few species are generators of patulin, one of the more benign mycotoxins.

Acetic Acid Bacteria

Bacteria that have the ability to oxidize ethanol into acetic acid are members of the genus *Acetobacter* and *Gluconobacter*.. Acetobacters have the ability to oxidize acetic acid further to $C0_2$ and water while the gluconobacters produce acetic acid as their final metabolic product from ethanol (Table 2).

Our studies have shown that low numbers of acetic acid bacteria are common contaminants of Eastern-grown grapes as received from the vineyard (Table 3). Generally the gluconobacters were more common than the acetobacters. Both genera can build up in winery environments, especially when wines are exposed to air. One vulnerable site for their growth is the cap that is produced when wines are fermented on the skins. This is controlled by regular pumping of wine over the cap or by punching the cap down several times a day.

Acetic acid bacteria never enhance wine quality. In addition to their negative effects on flavor, acetic acid is an inhibitor of yeasts and thus can cause stuck fermentations.

Bottled wines are protected from spoilage by acetic acid bacteria due to their anaerobic environment and the presence of low levels of free sulfur dioxide.

Lactic Acid Bacteria

These organisms are classified into four genera based on their morphology and fermentation products (Table 4). The homofermentative strains produce mainly lactic acid from hexose sugars while the heterofermentative lactics produce lactic acid, a two carbon compound (ethanol or acetic acid) and carbon dioxide. The heterofermentative strains appear to be the more aciduric and thus more capable of growing in wines.

Lactic acid bacteria are considered to be bad microorganisms only when they have grown in bottled wines. Prior to bottling, winemakers often inoculate their musts and wines with commercial strains that can degrade malic acid to lactic acid and thus reduce the acidity of highly tart wines. Growth of these organisms also produces compounds that enhance wine flavor.

Lactic acid bacteria need a fermentable sugar for their growth and metabolism. Wines containing less than 2-3 g/L usually are not susceptible to spoilage.

Wines containing fermentable sugar are often treated with potassium sorbate to prevent refermentation by yeasts. Unfortunately many lactic acid bacteria have the ability to reduce sorbic acid to sorbyl alcohol which then reacts with ethanol to form 2-ethoxy-3,5-diene. This latter compound imparts an odor similar to geranium, the common house plant. It is not appreciated by most wine drinkers.

Table 1. Effect of SO_2 on "Wild" Yeast Populations

Must Treatment	**Viable Yeasts/ml**
None - Control	4,700,000
100 mg/L SO_2 - 1 hr exposure	130,000
100 mg/L SO_2 -24 hr exposure	86

Table 2. Differentiation of Acetic Acid Bacteria

	Gluconobacter	***Acetobacter***
Flagella	Polar or none	Peritrichous or none
Ethanol to Acetic acid	+	+
Acetic acid to CO_2	-	+
Lactic acid to CO_2	-	+

Table 3. Incidence of Acetic Acid Bacteria on Eastern Grapes

Bacteria/10 grams	**No Samples**	**Percent**
<1	100	79
1 to 10	22	18
10 to 100	3	2
>100	1	1

Table 4. Important Genera of Lactic Acid Bacteria

Genus	**Morphology**	**Fermentation**
Pediococcus	Coccus-tetrad	Homofermentative
Streptococcus	Coccus-chains	Homofermentative
Leuconostoc	Coccus-pairs	Heterofermentative
Lactobacillus	Rods	Hetero- & Homo-Fermentative

TIME OF CLUSTER THINNING — VIDAL

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Several of the most widely planted French-American hybrid grapes tend to overcrop. The heavy crops, if left unadjusted, tend to decrease vine vigor and ultimately yields to unprofitable levels. Grapes from over-cropped vines tend to have low soluble solids and often result in inferior wines. Crop on many grape cultivars can be adequately controlled by pruning. However, the French-American hybrids produce fruiting shoots from latent non-count buds and also produce multiple clusters on shoots arising from count buds. These characteristics make it difficult to predict crop from the number of buds left at pruning and additional crop control is necessary to develop a vine with the desirable balance of vegetative growth and cropping.

Based on results from early research, OARDC has long recommended cluster thinning as a satisfactory means of adjusting crop to the proper level. The results have clearly indicated that thinning to one cluster per shoot is the treatment of choice. Cluster thinning is normally performed around bloom as the clusters are easy to see and remove. However, it is unclear if other times might provide an equal or greater benefit. In addition, the question often arises "If I didn't get it done at bloom, how late can I do it and still get the benefits?"

The two studies reported here were designed to answer these questions. The first study conducted in 1987-1989 evaluated cluster thinning prebloom and one or two weeks post-bloom on mature Vidal vines pruned to leave 16 shoots/foot of row. Each shoot was thinned leaving one (usually the basal) cluster. In the second study, conducted in 1996 through 1999, cluster thinning was compared to an unthinned control and thinning performed at bloom, bloom + 2 weeks, bloom + 4 weeks and bloom + 8 weeks. The latter was very close to veraison in most years. This study was conducted on mature Vidal vines that had been regularly cluster thinned to achieve a 6 ton/acre crop. In the present study all vines were pruned to allow 50 shoots and thinning was to one cluster per shoot.

In the early study there was no difference in yield with cluster thinning time in 1987, but in subsequent years prebloom thinned vines had slightly higher yields than thinning later (Figure 1A). Overall yield increased slightly over the years at all 3 cluster thinning times. Most of the response in yield could be explained by the increase in cluster weight over the years at all 3 times of cluster thinning (Figure 1B). There was a slight tendency for soluble solids to be slightly higher at 2 weeks after bloom in 2 out of the 3 years (Figure 1C).

The vines appeared to compensate and adjust to cluster thinning with increased yields and cluster size even though the number of clusters per vine were held constant. The slightly lower yields achieved by cluster thinning 2 weeks after bloom were associated with the small increase in

soluble solids.

In the second experiment conducted over 4 years beginning in 1996, yield per vine was decreased by all times of cluster thinning compared to unthinned control vines (Figure 2A). All times of cluster thinning resulted in an increase in cluster weight (Figure 2B), which was closely associated with the reduction in cluster number per vine. Juice soluble solids was higher on all cluster thinned vines. Interestingly there was no difference among the times of cluster thinning on any of these parameters even though time ranged widely from bloom to very near veraision (BL + 8 wks). Berry weight was higher on vines thinned 2 weeks after bloom than on vines either unthinned or cluster thinned 8 weeks after bloom. There was no difference in TA among the treatments. However, juice pH tended to increase as time of cluster thinning was delayed and juice from all cluster thinned vines had higher pH values than the unthinned control.

With the rather significant effects on yield and fruit quality achieved by cluster thinning, it is interesting that vine growth as judged by pruning weight was not different among the treatments (Figure 3).

One of the striking aspects of these two studies was how the vines adjusted and changed their production in response to the treatments. Prior to starting the study all vines had been cluster thinned so in 1996 there was a large potential for a heavy crop and the unthinned control vines produced 10.6 tons/acre. Vines responded negatively to this crop and the following year unthinned vines produced only 4.6 tons/a, but recovered in subsequent years producing 7.8 and 9.8 tons/a. Cluster thinning at any time in the initial year (1996) produced only 40-45% as much as the unthinned control vines (Figure 4). But by thinning 2 to 8 weeks after bloom in subsequent years, yields of the cluster thinned vines were nearly 80% of the unthinned vines and this fruit had higher soluble solids and pH that likely would have made higher quality wine. Yield per vine also increased in the earlier study with the greatest effects on vines thinned slightly before bloom. However, in the later study vines thinned at bloom adjusted less than vines thinned later in all years except the last (1999) when there was no difference.

In summary, cluster thinning was successful in reducing yield and improving quality in these two studies. Although there may be a slight advantage of thinning around bloom, a critical time was not identified and nearly equivalent affects were achieved by cluster thinning to nearly veraision. This study shows that desirable effects can be accomplished over a rather long time period and not just at the very busy time around bloom.

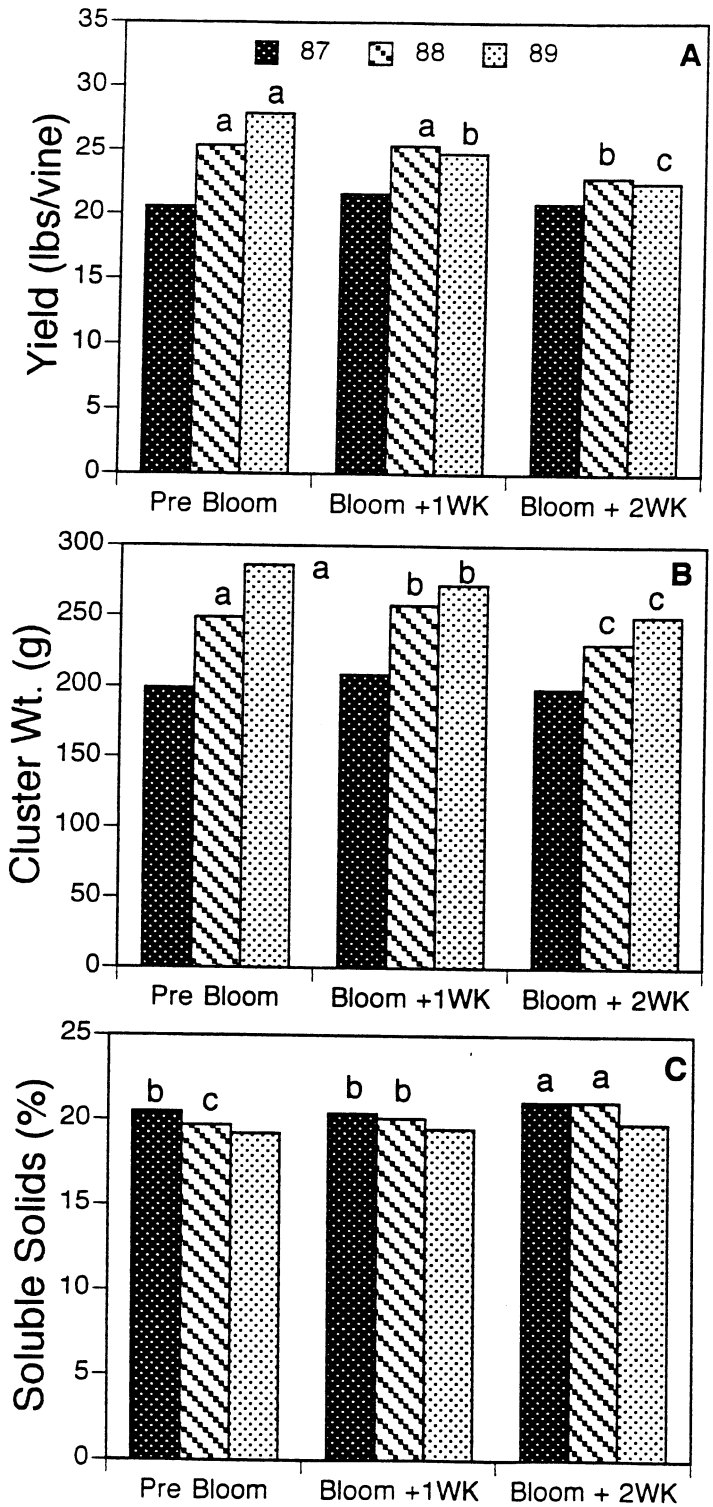

Figure 1. Influence of time of cluster thinning around bloom on Vidal vines on yield, cluster weight and soluble solids over 3 years (1987-1989).

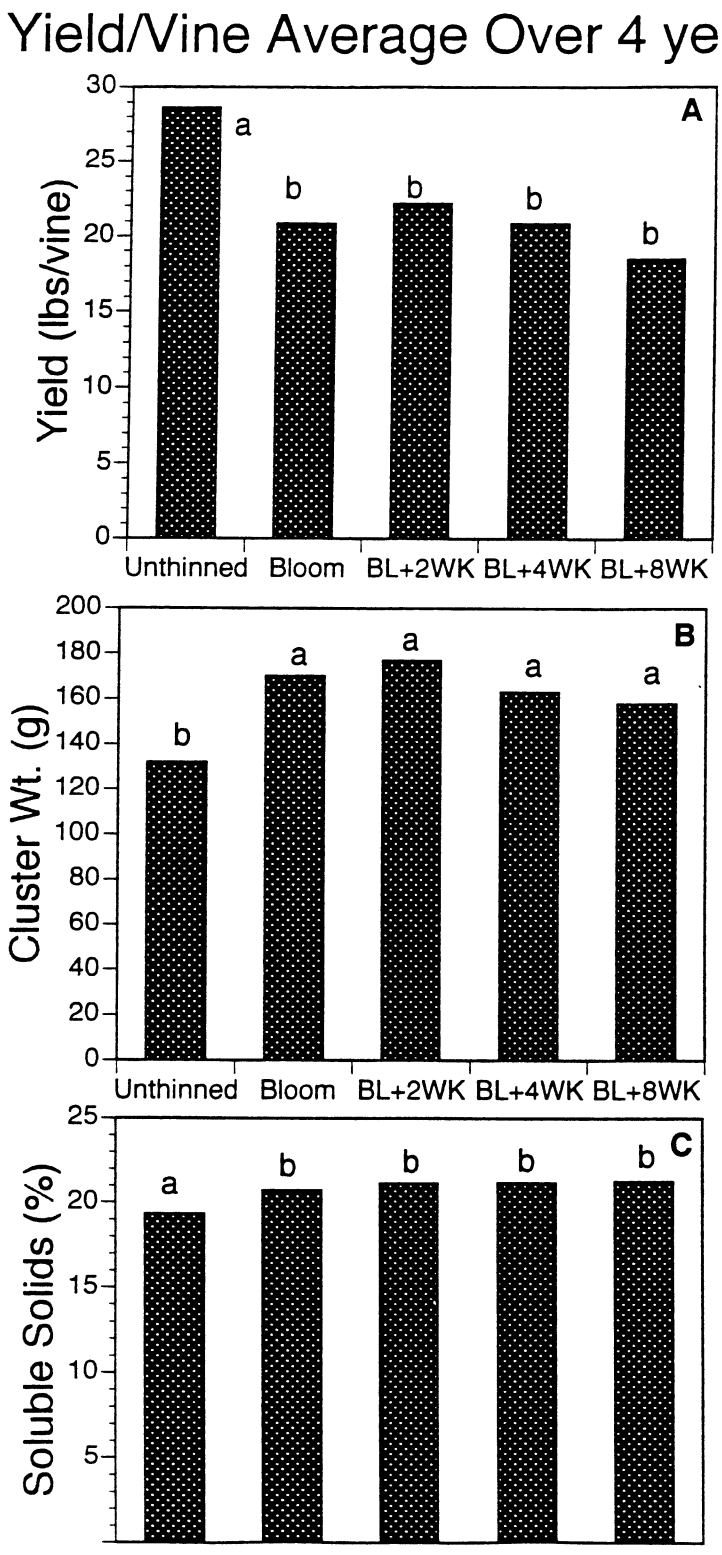

Figure 2. Influence of time of cluster thinning over a long period of the growing season on yield, cluster weight and soluble solids of Vidal vines over 4 years (1996-1999)

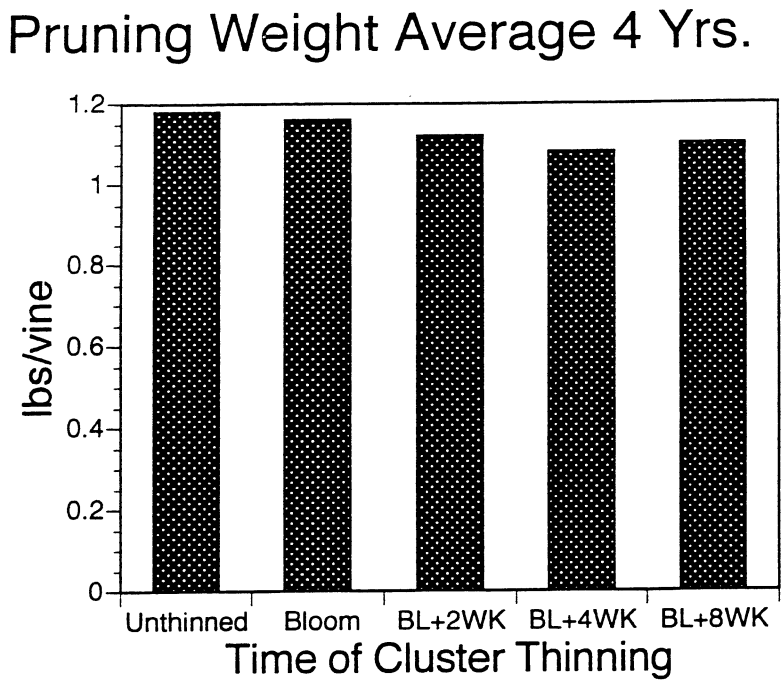

Figure 3. Pruning weight of Vidal vines as influenced by cluster thinning over 4 years.

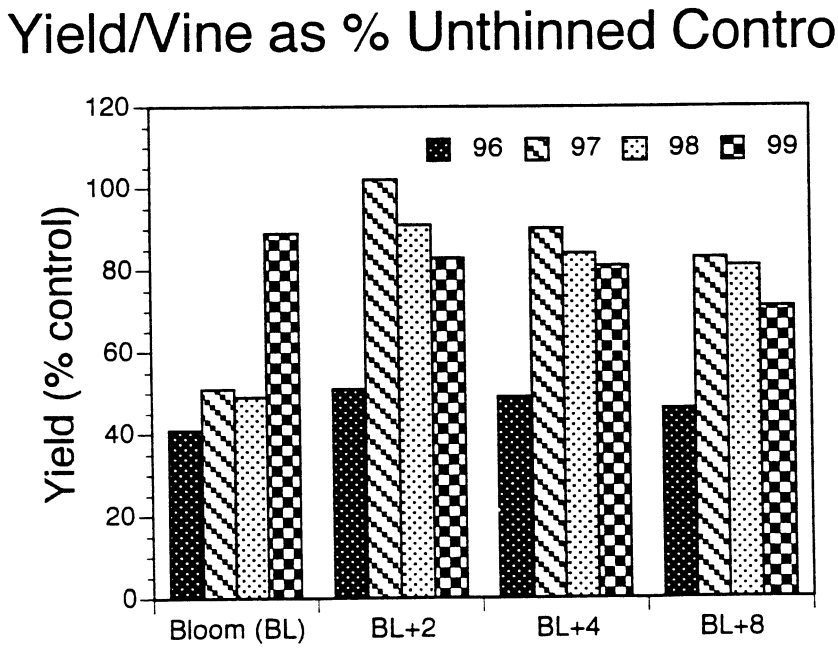

Figure 4. Yield of Vidal vines as a percentage of the unthinned control vines as influenced by cluster thinning at various times over the growing season.

DEVELOPING AN EFFECTIVE FUNGICIDE SPRAY PROGRAM FOR WINE GRAPES IN OHIO

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The following information is intended to be "food for thought" in relation to developing a fungicide spray program for wine grapes in Ohio. The spray schedule presents various fungicide options that can be considered by growers. It is important to note that the schedule is intended to provide simultaneous control of black rot, powdery mildew, downy mildew and Phomopsis cane on leaf spot. The schedule is also intended to provide fungicide resistance management, primarily against the powdery mildew fungus. Note that there are usually several fungicide options that can be selected. This schedule does not contain all of the fungicides currently registered for use on grapes. Remember, these are only "Suggested Guidelines" for use in developing a fungicide program. The final program that you develop will depend upon the disease complex in your vineyard as well as economic considerations.

SUGGESTED GUIDELINES FOR DEVELOPING A FUNGICIDE SPRAY PROGRAM FOR WINE GRAPES IN OHIO

This program is intended to provide simultaneous control of Block Rot, Powdery Mildew, Downy Mildew and Phomopsis Cane and Leaf Spot, as well as Fungicide Resistance Management

Application Timing	Material (and rate/A)
1 inch shoot	Mancozeb (3 lb/A)

NOTE: Mancozeb alone for Phomopsis only. If Powdery Mildew is a concern this early in the growing season, use:

Mancozeb (3 lb/A)
PLUS
A sterol-inhibiting fungicide
[Elite (4 oz/A) or Rubigan (3 fl. oz/A) or Nova (4 oz/A)]
or
Flowable Sulfur 6F (4 qt/A)
or
Wettable Sulfur (8-10 lb/A)

3-5 inch shoot or 10 days after last spray	Mancozeb (3 lb/A) PLUS A sterol-inhibiting fungicide [Elite (4 oz/A) or Rubigan (3 fl. oz/A) or Nova (4 oz/A)] or Flowable Sulfur 6F (4 qt/A) or Wettable Sulfur (8-10 lbs/A)

NOTE: If Powdery Mildew is a major concern, Rubigan, Elite or Nova are the fungicides of choice to combine with Mancozeb. Also, be aware that the efficacy of Sulfur for Powdery Mildew control declines below 65°F. If cool temperatures persist (below 65°F), Rubigan, Elite or Nova should be used instead of Sulfur for Powdery Mildew early in the growing season. On Sulfur sensitive varieties, use Rubigan, Elite or Nova. If Powdery Mildew is not a problem, Mancozeb alone can be used.

NOTE: Always check the price (cost per acre per application) of each fungicide. At the rates recommended, fungicides may vary considerably in cost.

10-12 inch shoot or 10 days after last spray	Same fungicides as 3-5 inch shoot
Immediate prebloom or 10 days after last spray	(Strobilurin Fungicide) Abound (11-12 fl oz/A) OR Sovran (4 oz/A)

NOTE: It is important to alternate different fungicide chemistry in the program in order to prevent the development of fungicide resistant strains of fungi, especially powdery mildew. Our intention here is to alternate the sterol-inhibiting fungicides (Rubigan, Elite or Nova) with the strobilurin fungicides (Abound or Sovran).

First postbloom spray no longer than 10-14 days after last spray	(Strobilurin Fungicide) Abound (11-12 fl oz/A) OR Sovran (4 oz/A)

Second postbloom spray no later than 10-14 days after last spray	Mancozeb (4 lb/A) PLUS A sterol-inhibiting fungicide [Elite (4 oz/A) or Rubigan (5 fl. oz/A) or Nova (4 oz/A)] or Flowable Sulfur 6F (4 qt/A) or Wettable Sulfur (8-10 lb/A)

NOTE: In order to prevent or delay the development of fungicide resistance, the sterol-inhibiting fungicides (Rubigan, Elite or Nova) and the strobilurin fungicides (Abound or Sovran), each class of fungicide should not be used more than 3 to 4 times (preferably 2-3 times) per season.

Summer Sprays Should Not Exceed a 14-Day Interval

Third post bloom spray 10-14 days after last spray	(Strobilurin Fungicide) [Abound (11-12 fl. oz/A) or Sovran (4-6.4 oz/A)] OR Mancozeb (3-4 lb/A) or Captan 50W (3-4 lb/A) PLUS Flowable Sulfur 6F (4 qt/A) or Wettable Sulfur (8-10 lb/A)

NOTE: A sterol-inhibitor fungicide (Rubigan, Elite or Nova) can be used postbloom for Powdery Mildew control; however, season long use of the sterol-inhibitors will greatly increase the risk of fungicide resistance development. Especially if early season disease control is good, emphasis for Powdery Mildew control later in the season should be placed on Sulfur, a Strobilurin fungicide (Abound or Sovran),a fixed copper fungicide or JMS-stylet oil.

NOTE: No more than 4 applications of a Strobilurin fungicide can be made per season.

NOTE: Watch the 66 days PHI on Mancozeb. If you get within 66 days of Harvest, Captan can be used in place of Mancozeb. The danger of black rot infection should be over by this time. Berries should be resistant to black rot. The Mancozeb or Captan is included for downy mildew control only. If downy mildew is a problem, the high rate of Sovran should be used.

Fourth post bloom spray 10-14 days after last spray These fungicide choices will be used through harvest	(Strobilurin Fungicide) [Abound (11-12 fl.oz/A) or Sovran (4-6.4 oz/A)] OR Captan 50W (3-4 lb/A) PLUS Flowable Sulfur 6F (4 qt/A) or Wettable Sulfur (8-10 lb/A) OR Fixed Copper Fungicide used alone

NOTE: If dry weather persists and the risk of Downy Mildew is low, Mancozeb or Captan should not be required and Sulfur can be used alone for powdery mildew control. If weather is wet and Downy is a problem, a Downy Mildew material needs to be included. A Fixed Copper Fungicide will give good control of both Downy and Powdery Mildew. Especially on susceptible varieties, powdery mildew will need to be controlled throughout the growing season.

NOTE: For Botrytis bunch rot control, the following fungicides are available:

Rovral (1.5 lb/A)
PLUS
Latron B1956(6 fl oz/100 gal)
OR
Vangard (10 oz/A) used alone
OR
Elevate (1 lb/A) used alone

These will be used only on bunch rot prone cultivars. The first spray should be made when disease is first observed or at veraison (or shortly thereafter). Then wait until a combination of threatening weather and/or disease develops and make a second spray (at least 2 weeks after the first spray). On late maturing varieties a third spray may be required.

NOTE: Some tests in New York have indicated that Rovral at 1 lb/A plus Vangard at 5 oz/A may have an additive effect and provides good bunch rot control. The use of a strobilurin fungicide during the bloom period may provide some control of Botrytis.

NOTE: The strobilurins (Abound, and Sovran) cannot be applied more than 4 times per season on wine grapes, and 3 times per season on all other types of grapes (juice). The label also states "do not apply more than 3 sequential sprays of any strobilurin fungicide before alternating with a fungicide that has a different mode of action".

NOTES ON NEW FUNGICIDES FOR GRAPE DISEASE CONTROL

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Several new fungicides have recently been registered in the U.S. for use on grapes. Much of this new chemistry is highly effective for control of many of our major grape diseases, and should prove to be valuable tools for use in our grape disease management program. The following information provides a brief description of these new fungicides.

Strobilurin fungicides

The strobilurin fungicides represent a new class of fungicide chemistry that is highly effective for controlling many of the major fungal diseases of grapes in the Midwest. The strobilurin fungicides were first discovered or isolated from wood-decaying mushrooms, such as *Strobilurus tenacellus.* This new class of chemistry is a valuable addition to our current arsenal of fungicides for grape disease management. Perhaps one of the most exciting characteristics about the strobilurins is their spectrum of activity. Most of them are registered for control of black rot, downy mildew, powdery mildew, and Phomopsis cane and leaf spot. Some recent research suggests that they have fair to good activity for control of Botrytis. Although these materials do have a very broad spectrum of activity (control a large variety of fungi), they do differ in their activity to specific diseases. All of them have good activity against black rot and powdery mildew. None of them are highly active against Phomopsis cane and leaf spot, and they vary greatly in their activity against downy mildew. Even though they differ in their activity to specific fungi, they will be important tools for use within the grape disease management program. Until now, we have never had a fungicide that would provide simultaneous control of all of these diseases. Prior to the development of the strobilurins we had to rely on tank-mixes of fungicides to control all these diseases. For example, the sterol-inhibiting fungicides such as Nova provide excellent control of black rot and powdery mildew, but are not effective against downy mildew or Phomopsis. Thus, we have recommended a tank-mix of Nova plus mancozeb to control all of these diseases simultaneously. The Nova for black rot and powdery mildew and the mancozeb for downy mildew and Phomopsis.

The strobilurins are very good protectant fungicides. They have good residual activity and have provided good control in 10-14 day spray schedules. They are also "locally" systemic and provide some level of "after-infection" activity. One problem with the strobilurins is that they are at high risk for fungicide resistance development. Fungicide resistance development is a serious problem we are facing with these new fungicides, as well as our previously registered materials such as the sterol-inhibitors (Bayleton, Nova, Rubigan, Procure, and Elite). When Bayleton was first registered in the U.S., it could be used at 2oz product per acre on a 21-day schedule and provide excellent powdery mildew control. After years of continual use, the powdery mildew fungus has developed a high level of resistance to Bayleton. Although Bayleton is still highly effective for control of black rot, we no longer recommend its use for powdery mildew control in

Ohio.

The remaining sterol-inhibiting fungicides are also facing the threat of fungicide resistance developed by the powdery mildew fungus. This is another reason why the introduction of the strobilurin fungicides is extremely timely. Strobilurin chemistry is very different from chemistry of the sterol-inhibiting fungicides. In short, they attack the fungus in a very different way. One of the main recommendations for preventing or slowing down the development of fungicide resistance is to alternate the use of different fungicide chemistries in the spray program. The introduction of the strobilurins allows us to do that. Alternating strobilurin fungicides with a sterol-inhibiting fungicide combined with a good protectant fungicide will probably become a standard recommendation in fungicide programs for wine grapes in the Midwest. Further information on fungicide resistance management will be provided as we discuss each of these new strobilurin fungicides individually. There are three strobilurin fungicides currently registered for use on grapes. They are: Abound (azoxystrobin); Sovran (kresoxim-methyl); and Flint (trifloxystrobin). Although Abound, Sovran and Flint are all closely related and are all excellent fungicides, they do differ to some extent in their effectiveness against specific diseases. In addition, some of them have specific or "special" problems that grape growers need to be aware of.

Abound (azoxystrobin)

Abound flowable (2.08F) was first registered in the U.S. in 1997. Thus, most growers have some degree of experience with Abound, and all the grower comments I have heard have been quite positive. Abound is registered for control of Black rot, powdery mildew, downy mildew, and Phomopsis cane and leaf spot. It provides good to excellent control of all these diseases except Phomopsis, for which it provides fair control. Research in New York indicates that it provides fair to good control of Botrytis bunch rot. The following information was taken from the label.

> Begin ABOUND flowable applications prior to disease development and continue applications throughout the season every 10 to 14 days. For resistance management: Do not apply more than 3 sequential sprays of Abound before alternating with a fungicide that has a different mode of action. For wine and table grapes, do not make more than 4 applications per acre per year. For all other types of grapes do not make more than 3 applications per acre per year. Do not apply within 14 days of harvest. NOTE: ABOUND Flowable is very phytotoxic to apples of the variety McIntosh or varieties related to McIntosh. Do not use the same sprayer to apply ABOUND to grapes that will be used to apply other materials to apples. Do not allow spray to drift from grapes to apples.
>
> **Please note that label information is subject to change. Always read the most recent label.**

The problem with phytotoxicity to apples can be very serious. In Ohio, this is not much of a problem because most grape growers do not produce apples. This could change to some extent in the future. In states like New York, Michigan and Pennsylvania, where several grape growers also grow apples or where vineyards are situated next to apple orchards, the phytoxicity is a serious concern and significant losses have occurred in a few orchards. Abound is registered for

use at 11 to 15.4 fluid oz/A. In the last couple of years, Ohio growers have used Abound at the rate of 11 to 12 fluid oz/A on a 10 to 14 day schedule with good results. Abound is excellent for control of black rot and downy mildew. It provides fair to good control of powdery mildew, but is weaker against powdery mildew than Sovran or Flint. It is stronger against downy mildew than Sovran or Flint. None of the strobilurins appear highly effective against Phomopsis, and they all have some activity against Botrytis. Abound is a product of Zeneca Corp.

Sovran (kresoxim-methyl)

Sovran 50WG fungicide was recently registered (1999) for use on grapes for control of Phomopsis cane and leaf spot, black rot, powdery mildew, and downy mildew. Sovran is a product of BASF Corp. and was the second fungicide in this new class of chemistry (strobilurin) to be registered for use on grapes in the U.S. Sovran is similar to Abound in that it provides good to excellent control for most of our major grape diseases. Unlike Abound, Sovran is not phytotoxic (damaging) to McIntosh apples and other related apple varieties. Although Sovran and Abound are closely related and both are excellent fungicides, they do differ in their effectiveness against certain diseases. Both Abound and Sovran provide very good control of black rot with about equal efficacy. Both fungicides are also very effective against powdery mildew; however, Sovran is more active against powdery than Abound. The biggest difference is with downy mildew. Abound is more effective for control of downy mildew than Sovran. Sovran will provide good control of downy if the highest label rate is used (6.4 oz/A). Sovran is registered for use at 3.2 to 4.8 oz/A for black rot, 3.2 to 4.8 oz/A for powdery mildew, and 4.0 to 6.4 oz/A for downy mildew. The 4 oz/A rate has provided good control of black rot and powdery mildew in fungicide trials. Obviously, using the higher rate of 6.4 oz/A for control of downy mildew will greatly increase cost. Both Sovran and Abound will provide only fair control of Phomopsis, and both have at least fair activity against Botrytis.

The following information was taken from the label.

Use **Sovran* fungicide** as a protective spray at 3.2-6.4 ounces per acre. Make applications of **Sovran* fungicide** in sufficient spray volume to ensure thorough coverage. Do not use less than 10 gallons of water per acre. Black rot and *Phomopsis* cane and leaf spot control should begin at bud break and continue on a 14-day schedule through 1/4-inch berry. Use 4.8 ounces of **Sovran** per acre during periods of heavy infection pressure.

For powdery mildew control, begin sprays at bud break and continue on a 14-day schedule. Form more susceptible grape varieties or under conditions that favor rapid powdery mildew development, use 4.8 ounces of **Sovran** per acre. When disease pressure is low, the spray interval can be extended up to 21 days.

For downy mildew control, begin sprays at bud break and continue on a 7-10 day schedule. Under conditions that favor severe downy mildew development, use 6.4 ounces of **Sovran** per acre.

Crop-Specific Restrictions and Limitations

To limit the potential for development of resistance:

*On wine and table grapes, do not make more than four (4) applications of **Sovran** or other strobilurin fungicides per season. On grapes for other uses, do not make more than three (3) applications per season.

*Do not make more than 3 sequential applications of Sovran.
*Apply **Sovran** in alternation with non-strobilurin fungicides with a different mode of action.
Sovran cannot be applied within 14 days of harvest.
Please note that label information is subject to change. Always read the most recent label.

Flint (trifloxystrobin)

Flint 50WG fungicide was also registered for use on grapes late in 1999. Like Abound and Sovran, Flint is also a strobilurin fungicide. Flint is registered for control of black rot and powdery mildew. It is registered for "suppression" of downy mildew and is not registered for control of Phomopsis. Of all the strobilurins, it has the best efficacy for control of powdery mildew. The use of Flint for grape disease control in Ohio has been limited due to the following factors:

1) Flint cannot be used on Concord grapes. The label states **"Do Not Apply Flint to Concord Grapes or Crop Injury May Occur"**; and
2) Flint is not highly effective for control of Downy mildew. In fact the label states that it provides "Disease Suppression" not control of Downy mildew.

For these reasons, Ohio growers will probably select Abound or Sovran as the strobilurin fungicide of choice for use on grapes. In growing regions such as California where downy mildew is not a problem and Concord grapes are seldom produced, the use of Flint is more practical. If Concord grapes are not a problem and the main diseases of concern are black rot and powdery mildew, Flint will do an excellent job in the Midwest.

The following information was taken from the label.
Grapes: Do not apply Flint to Concord grapes or crop injury may occur.
Flint is registered for use at 1.5 to 2 oz/A for powdery mildew control, 2 oz/A for black rot control and 4 oz/A for suppression of downy mildew.
Restrictions: Do not apply more than 8 oz. of Flint per acre per season. Do not apply Flint within 14 days of harvest. Do not apply more than 4 applications of Flint or other strobilurin fungicides to table or wine grapes per season. On grapes for all other uses, do not apply more than 3 applications of Flint or other strobilurin fungicides per season. To limit the potential for resistance to develop, do not apply more than 3 sequential applications of Flint or other strobilurin fungicides before alternating to a non-strobilurin fungicide.
Note that both Sovran and Flint cannot be applied more than 4 times per season on wine and table grapes, and 3 times per season on grapes for all other uses. The label also states do not make more than 3 sequential applications without alternating with a non-strobilurin fungicide with a different mode of action.

The reason for these restrictions is to prevent the development of **Fungicide Resistance.**

In summary, all of the strobilurins are excellent fungicides; however, each has certain

distinct characteristics. Cost and the various "special" characteristics of each fungicide will help to determine which is used. The important thing to note is that these are excellent fungicides and should be incorporated into our fungicide spray program for grapes in the Midwest.

Fungicides For Control of Botrytis Bunch Rot

Vangard Fungicide (Cyprodonil) and Elevate fungicide (Fenhexamid) were both recently registered for control of Botrytis bunch rot. These are welcome newcomers to our arsenal of fungicides for Botrytis control, which is actually very sparse. At present, Rovral, Benlate, Vangard, and Elevate are the fungicides recommended for bunch rot control. Many growers no longer use Benlate due to the development of fungicide resistance. Rovral has been the "Cadillac" fungicide for Botrytis control, but concerns over fungicide resistance development also exist with Rovral. This makes the registration of these new fungicide chemistries (Vangard and Elevate) especially important. Where resistance is not a problem, Rovral is still an excellent Botrytis material. The efficacy of Vangard and Elevate is similar to that of Rovral. Vangard and Elevate are both good Botrytis materials. However, in several fungicide trials, Vangard appears to be slightly more efficacious than Elevate.

Vangard is registered for use at 10 oz/A when used alone or 5 to 10 oz/A when used in a tank mix. More than 20 oz. of Vangard cannot be applied per acre per crop season, and Vangard can not be applied within 7 days of harvest. Vangard fungicide is a product of Novartis Crop Protection. To prevent fungicide resistance development to these fungicides (Rovral, Elevate, and Vangard), they should be tank-mixed or alternated with each other in the spray program for Botrytis bunch rot control. Some research in New York suggests that there may be an additive effect from tank-mixing (half rates) of Rovral at 1 lb/A with Vangard at 5 oz/A.

Elevate 50WDG fungicide was registered for control of Botrytis bunch rot on grapes in 1999. Elevate is a product of Tomen Agro, Inc. and has good activity against Botrytis. Elevate is different chemistry than Vangard, Rovral, and Benlate.

The label states that for control of Botrytis bunch rot (gray mold) apply 1 lb. Product per acre. The final application may be made up to and including the day of harvest (PHI=0 days). Do not apply more than 3 pounds of product per acre per season. Thus, you can not make more than 3 applications per season.

In summary, all of these "Botrytis" materials are costly and should be used correctly and only on the tight-clustered "more valuable" wine grapes that are highly susceptible to Botrytis. Especially where Rovral has been used for many years, or where the efficacy of Rovral for Botrytis control appears to be reduced, these new materials (Vangard and Elevate) should be introduced into the fungicide program for Botrytis control.

CONCERNS ABOUT *ESCHERICHIA COLI* IN GRAPE JUICE

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Escherichia coli is a common resident of the intestinal tract of animals. Most strains are not pathogenic to humans. Some, however, are responsible for gastrointestinal illnesses.

E. coli serotype O157:H7 is one of the more pathogenic strains. This organism, first recognized as a pathogen in 1982, produces some of the most severe infections ranging from bloody diarrhea to hemolytic uremic syndrome to involvement of the pancreas, the latter which may later lead to diabetes.

Ground beef and other meat products are a common vehicle of infection. The bacterium has the ability to survive for extended time periods in acid environments such as apple cider and contaminated ciders have been responsible for illness outbreaks.

Death kinetics

When microorganisms are placed in an adverse environment they die off logarithmically. As a result, a plot of the log count of living cells against time will give a straight line. A 1 log reduction in count means that 90% of the cells have died, a 2 log reduction equals a 99% die off, etc. These die-off rates are expressed as D-values (Table 1). It has been recommended that pasteurization or other lethal treatments for the control of O157:H7 should produce a reduction of 5 log cycles, thus a 99.999% kill.

D-values in ciders

Our studies with cider have shown that the die-off rates vary with the type of cider and with the holding temperature. It can be seen (Table 2) that typical D-values were about six days at 20° C. A five log reduction, therefore, would require the cider to be held for about 30 days before it would be safe to drink. Even longer storage would be required at refrigeration temperatures to achieve this leathality. These results explain why unpasteurized ciders have been responsible for a number of O157:H7 outbreaks.

Die-off rates in grape juice and wines

Our studies indicate that *E. coli* dies off much more rapidly in grape juice than in cider. Thus D-values in white and red grape juices were less than 24 hours (Table 3) whereas die-off in ciders was expressed in days. Why grape juice presents a more hostile environment is not understood. D-values do not appear to be related to pH or the soluble solids content.

Our research on the survival of three different strains of O157:H7 in a white 68° Brix grape concentrate yielded D-values ranging from 19 to 32 hours (Table 4). Thus the die-off rates were similar to that obtained in single strength juice.

Fermented grape juice, on the other hand, presented a much harsher environment in that less than 30 minutes were required to achieve a 90% reduction in viable counts (Table 5). The factors responsible have not been determined. It is possible that a combination of alcohol content and free sulfur dioxide contributed significantly to the wine's lethality.

Controlling *E. coli* in fruit juices

Although our data to date indicate that O157:H7 poses little health problems in grape juices and wines, it is possible that more resistant strains may be discovered in the future. The following are controls that might be effective:

Pasteurization. Our studies with different apple ciders have shown that 10 seconds at 160° F will produce over a 5 log reduction without adversely affecting flavor. Ciders given this treatment still require refrigeration, however, because other spoilage microorganisms will survive the process.

Ultra-violet. Juices with high pigmentation and/or suspended solids are difficult to treat because they are refractive to penetration by UV rays. However, newly designed units measure UV penetration and then automatically adjust flow rates to achieve the desired lethality. Research by my colleague, Dr. Randy Worobo, has shown the equipment to be highly effective against *E. coli* as well as other microbial pathogens of cider.

Sulfur Dioxide. Most winemakers are well acquainted with this compound which generally is added to grape juice as a gas or as the salt, potassium metabisulfite. Our studies with cider have shown that as little 50 mg/L sulfur dioxide is lethal to O157:H7 when the pH is under 3.5. The latter is important (Table 6) because it is the undissociated molecule that has the germicidal effect.

Dimethyldicarbonate. This is another germicidal compound that is used in winemaking. Our research with ciders indicates that it can readily produce a five log reduction of viable counts of O157:H7 and other pathogenic microorganisms..

Table 1. D-values versus percent of die-off

D-value	Per cent Death
1	90
2	99
3	99.9
4	99.99
5	99.999

Table 2. Survival of *E. coli* O157:H7 in cider at 20° C

	D-value Days
Red Delicious	6.9
McIntosh	6.3
Empire	5.8
Northern Spy	1.6

Table 3. D-values in SO2-free grape juice at 20° C

Grape Variety	pH	°Brix	D-value (Hr)
Cayuga White	2.8	17	20
Elvira	3.4	16	14
Chardonnay	3.3	23	21
Seyval	3.2	22	23
Concord	3.2	10	21
Cabernet Sauvignon	3.7	24	21
Gamay Beaujolais	3.3	21	22
Early Burgundy	3.5	18	20

Table 4. Survival of O157:H7 in 68° Brix White Grape Juice Concentrate at 20° C

E. coli Strain	D-value (Hrs)
43895	32
933	19
43889	26

Table 5. Survival of *E. coli* O157:H7 in Wines at 20° C.

Wine	%Ethanol	D-value (Mins)
Seyval	11	24
Seibel 1000	11	17
Cabernet sauvignon	12	12
Pinot noir	10	22

Table 6. Lethality of Sulfur Dioxide Toward *E. coli* O157:H7 in Cider of pH 3.3.

S02 mg/L	D-value (Hr)
0 Control	240
1.55	
0.88	
0.79	

INTEGRATED GRAPE DISEASE CONTROL IN NEW YORK (AND HOW WE INCORPORATE NEW FINDINGS)

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In New York, we have five major fungal diseases that must be controlled on at least some varieties every year: Phomopsis cane and leaf spot, powdery mildew, black rot, downy mildew, and Botrytis. Fortunately, anthracnose is not an issue for us. We have found that the key to developing an efficient, integrated "package" for managing these diseases is to understand:

- The fundamental biology of the major diseases, (weather effects, how they spread, etc.)
- Factors that influence the crop's susceptibility to infection (we concentrate heavily on identifying the critical periods for controlling infection during the season)
- The basics of the fungicides that you use in your control programs (protectant or systemic, spectrum of activity, risk of developing resistance, etc.)

Grapes are becoming an increasingly important crop in eastern North America and research into their culture (including disease management) is trying to keep pace with this development. Thus, I'll first discuss the above topics, with an emphasis on new findings, then try to integrate these various considerations into a total disease management program as we progress through the season.

PHOMOPSIS (Ph)

Biology. Phomopsis persists in old canes and wood (especially pruning stubs) that were infected in previous years. Thus, mechanical pruning systems that retain a lot of old canes and wood can increase pressure for this disease. The spores are splash-dispersed by rain, so disease spread is very local (within the vine) and tissues growing beneath old wood are at more risk than those growing above it. This is <u>one</u> reason that native grape varieties, with their pendulous growth habit, are plagued more by Phomopsis that upright-growing hybrid and vinifera varieties. Recent research suggests that the majority of the season's spores are released during the early part of the growing season, although this is not completely clear yet. Nevertheless, a year with abundant rain during the early part of the season significantly increases the danger of Phomopsis. The disease does not appear to spread from current-year infections during the growing season.

Susceptibility. We see the greatest problem on Niagara and Seyval grapes, although all varieties are susceptible to some degree. Our most consistent losses result from infection of the cluster stem (rachis), causing berries to drop before harvest. We've found that most control of these infections comes from early sprays, starting about 1-3 inches of shoot growth and again 2 weeks later. Fruit infection (looks like black rot but doesn't appear until just before harvest)

occurs sporadically in New York, but it can be severe in certain years. Recent research from Mike Ellis's group at OSU shows that fruit remain susceptible to infection all season, although serious fruit losses in New York occur primarily when the weather is very wet during the period from bloom through pea-sized berries.

Fungicides. The standard protectant fungicides (captan, mancozeb, ferbam, ziram) are the most effective and most economical choices. Experience has been mixed with the new strobilurins (Abound, Flint, Sovran). The DMI fungicides (Elite, Nova, Rubigan) are not effective, nor is sulfur. Copper is weak.

POWDERY MILDEW (PM)

Biology. The PM fungus overwinters in minute fruiting bodies lodged in the bark of the trunk and arms. Although the disease requires rain to get started, further disease spread does not require rain and is governed almost entirely by temperature. For instance, the generation time (i.e., the time it takes from when a spore lands on a leaf until a new round of spores is produced from the resulting infection) is 2-3 weeks at 50°F; it's only 5-7 days at 60-80°F; and the disease shuts down at temperatures above 90°F. This is a typical "compound interest" disease with explosive potential at moderate to warm temperatures, but control programs can be much looser during long cool periods in the spring or extended hot spells in the summer, should those occur (e.g., southern Ohio). New research has confirmed old observations that the disease is especially active in vineyards where the humidity is particularly high, e.g., next to lakes, stream banks, etc. Spread is by wind-blown spores that can travel long distances.

Susceptibility. Powdery mildew is a disease of young, juvenile tissues. Leaves are highly susceptible while they are expanding, but become resistant soon after they're fully expanded. Recent research has shown that berries are highly susceptible between bloom and fruit set, but become much more resistant afterwards; in fact, Concord berries become immune to infection after fruit set. In contrast, berries of V. vinifera cultivars retain some susceptibility until 5+ weeks after bloom, although severe cluster PM only results when infections occur during the first couple of weeks after bloom. Also, new research has shown that berry infections that occur near bunch closure remain almost invisible to the naked eye, but can promote infection by Botrytis and various sour rot organisms.

Fungicides. Sulfur is cheap and effective; because much of its activity is through the vapor phase, it's also temperature sensitive (relatively inactive at cool temps below 60°F, potentially phytotoxic at temps above 85°F). It doesn't control other diseases and can't be used on Concords.

The DMI fungicides (Bayleton, Elite, Nova, Procure, Rubigan) are "locally systemic" materials (they're absorbed quickly and move within that individual leaf or berry, but not throughout the plant). They do not inhibit spore germination, but attack the fungus during its early growth stage within the plant, thus they have some limited "kickback" activity. They have

been highly effective against PM, but their activity is declining in many regions due to increasing levels of resistance. Bayleton is always the first to go, and we no longer recommend it in New York. The other materials are still effective, but it is important to follow a few simple rules to minimize resistance development and maintain their usefulness (i) ALWAYS use full labeled rates with EXCELLENT spray coverage. This is particularly important, because resistance to the DMI fungicides is highly dependent on the rate delivered to the vine; (ii) Limit the seasonal use of these materials (ideally, a maximum of 3 applications per season); and (iii) Use these fungicides to maintain a clean vineyard, not to clean up a PM mess (the larger the PM population, the better the chance for selecting resistant individuals when you spray it).

The strobilurin fungicides (Abound, Flint, Sovran) are somewhere between a protectant and a systemic. They are bound tightly within the waxy layer on the surface of leaves and fruit, so are highly resistant to wash-off. They act not only by inhibiting spore germination (protecting against infection), but also by inhibiting the production of new spores from infections that do occur (thus, reducing disease spread). They are highly active against PM, and should be considered the "top dogs" in vineyards with a long history of DMI use. To minimize resistance development, labels specify a maximum of 3 (juice grapes) or 4 (wine grapes) applications per year, with no more than three sprays in a row. We concentrate their use on the critical period from bloom through bunch closure.

Because the PM fungus grows primarily on the surface of infected tissues, it is vulnerable to topical applications of several "alternative fungicides", including oils (JMS Stylet Oil, neem oil), salts (monopotassium phosphate [Nutrol], potassium bicarbonate), and hydrogen peroxide (Oxidate). In extensive tests with Nutrol, we've found little protective or residual activity, but we've found significant eradicative and anti-sporulant activity when applied on a relatively tight (7-day) schedule.

BLACK ROT (BR)

Biology. The BR fungus overwinters primarily as mummified fruit. Initial infections, which occur from one to several weeks after bud break through bloom, are caused by wind-blown spores that arise from these mummies. However, serious losses are due to disease spread within the vine, caused by other splash-dispersed spores that develop from new infections. BR has a very long incubation period (time from the start of the infection period until symptoms develop), i.e., 2-3 weeks on young berries and 3-5 weeks on somewhat older berries. This is important to recognize when trying to analyze "what went wrong" should black rot develop in the vineyard. The key to control is preventing infection on young berries, so that there is no opportunity for within-cluster spread before berries become resistant (see below). It's also important to prune out infected clusters during dormancy, and drop them from the canopy onto the vineyard floor.

Susceptibility. Berries are highly susceptible for the first 3 weeks after cap fall, then they become progressively more resistant with time. Concord berries become immune by the time they are 5 weeks old, whereas Riesling and Chardonnay berries can retain some susceptibility until they

are 6 to 7 weeks old. In numerous vineyard trials conducted since 1995, we have obtained virtually complete control with Nova applied only at the start of bloom plus 2 and 4 weeks later.

Fungicides. Mancozeb, ferbam, and ziram are effective protectants, but they are subject to wash-off and may need reapplication following a heavy rain. Nova and Elite are outstanding, we consider them the "gold standards". The strobilurin fungicides are more effective than the protectants (less wash-off?), but are slightly less effective than Nova and Elite. Rubigan, captan, and copper provide only partial control. Sulfur is ineffective.

DOWNY MILDEW (DM)

Biology. Primary infections can occur from 2-3 weeks before bloom until fruit set, so this is a critical time to prevent disease establishment. Once DM becomes established, it can spread rapidly by wind-blown spores. The disease is highly dependent on dewy nights followed by rainy days, and is favored by temps of about 65-77°F (no activity over 86°F). Under optimum conditions, the generation time is only 4-5 days, so this is another "compound interest" disease with explosive potential. Conversely, DM will "disappear" during hot, dry weather. It's a disease very much worth scouting for, to determine its current activity or the lack thereof before making a spray decision.

Susceptibility. As with PM, only relatively young tissues are susceptible to infection.

Fungicides. Among the protectant fungicides, mancozeb, captan, and copper are very effective; ferbam and ziram are only moderately effective. Among the strobilurins, Abound is highly effective, but Sovran is only moderately effective and Flint is weak. Ridomil is a systemic fungicide with outstanding efficacy, but it doesn't control any other grape disease. The DMI fungicides are completely ineffective against DM.

BOTRYTIS (Bot)

Biology. The Botrytis fungus is a weak pathogen that attacks dead, injured, or "expiring" tissues (wilting blossoms, ripening fruit). It infects fruit after veraison or much earlier through old blossom parts, in which case it remains "dormant" in the developing berries until they begin to ripen. The fungus thrives in high humidity and still air, hence the utility of cultural practices (e.g., leaf pulling) that combat these conditions. Fungicide sprays from veraison onwards protect against new infections; those from bloom through bunch closure protect against latent infections and from spore sources (infected blossoms) getting established within the cluster.

Susceptibility. See above. High nitrogen content also promotes this disease.

Fungicides. Most general fungicides are ineffective against Botrytis. All Botrytis-specific fungicides are prone to resistance development, and should be used in rotation with each other.

Rovral is a moderately systemic fungicide that has lost efficacy in many areas due to resistance. Where Rovral has been used intensively, it should be "rested" for a year or two, then used no more than once a year afterwards. Vangard is a new systemic fungicide with excellent activity; it is highly prone to resistance development, and ideally it should be used no more than once a year (twice is the legal maximum). Elevate is a new protectant fungicide with good activity; it also should be used no more than once or twice a year. The strobilurins show moderate activity against Botrytis, and may be sufficient during bloom through bunch closure if disease pressure is moderate.

PUTTING IT ALL TOGETHER

This is how we consider things as the season progresses. There will be many similarities in the cooler parts of Ohio (Lake Erie region) and probably some specific differences in the warmer southern part of the state (e.g., stronger BR and DM pressure, but less PM pressure in the midsummer). Weather conditions and disease history in a block will heavily influence these general considerations. Refer to the above discussion for specifics.

1-Inch shoot growth. A Ph spray may be warranted if wet weather is forecast and the training system or recent block history suggests high risk. Option A: Noting. Option B: Captan or mancozeb.

3-5 Inch shoot growth. A traditional time to control Ph shoot infections. Perhaps more importantly, recent evidence indicates that this also is an important time to control rachis infections, which can occur once clusters emerge. Time to start control of PM on vinifera varieties if temperatures consistently remain above 50^{0}F; also in highly susceptible hybrid blocks if crop value justifies it. A possible time to experiment with Alterative@ PM materials (salts, oils) if you're so inclined. BR control is seldom justified unless you're trying to clean up a problem block AND weather is wet. Option A: Nothing. Option B: Mancozeb (BR, Ph). Option C: Captan (Ph). Easier on predator mites than mancozeb (or ziram), but not as effective against BR (which usually isn't an issue this early). Option D: Nova or Elite (PM, BR). Use 3 oz/A for economy with so little foliage now (but remember that coverage becomes even more important when you're working with lower tank rates). Option E: Rubigan (PM). At 2 fl oz/A (minimal labeled rate), cost is only about $4. Cheaper than Nova and Elite, especially if BR control isn't an issue. Option F: Sulfur (PM). Not very active at temps below 60°F, but neither is the PM fungus. Doesn't control other diseases. Option G: JMS Stylet Oil (PM). Should eradicate young infections IF thorough coverage is provided. Can use with mancozeb (or ziram), but not with captan (phytotoxicity). Option H: Nutrol (PM). Should eradicate young infections IF thorough coverage is provided. Option I: One of the PM products plus mancozeb or captan for Ph (use mancozeb if BR control also is desired).

10-Inch Shoot Growth. Traditionally, we've recommended not to wait any longer to control BR. Continued experience tells us that this recommendation is conservative (the spray generally isn' t needed) unless BR was a problem last year and/or weather is unusually wet and

warm. Don't wait any longer to control PM on susceptible varieties (but wait until immediate prebloom on Concords). One of the best times to use an SI, but these aren't the only options. DM control will be needed on highly susceptible varieties if disease was prevalent last year and rains of at least 0.1 inches at temps >50°F occur. Rachis infections by Ph are a possibility, particularly if weather is wet and inoculum is present. Option A: Abound, Sovran, or Flint (PM, BR, some Ph; also, variable DM [Abound, excellent; Sovran, fair to good; Flint, poor to fair]. Not the most efficient time to apply these expensive and limited-use materials unless disease pressure is high. Option B: Mancozeb (BR, Ph, DM). A broad spectrum, economical choice if PM isn't a serious concern. Or tank mix with a PM material. Option C: Nova or Elite (PM, BR). Option D: Rubigan (PM). No BR but cheaper than Nova and Elite. Option E: JMS Stylet Oil (PM). If (and only if) coverage is thorough, this spray should eradicate early PM colonies that may be starting because previous PM sprays were omitted. At a retail cost of $11/gal, a use rate of 1% (1 gal oil /100 gal water), and 50 gal/A spray volume, cost is about $5.50/A. But don't waste your money if you can't cover thoroughly. Also may help with mites. Option F : sulfur (PM). Reduced activity at low temperatures is still an issue at this time of year. Option G: Nutrol (PM). Short residual activity, but has eradicative activity against recent infections. Same need for thorough coverage as JMS Stylet Oil. Option H: Mancozeb (BR, Ph, DM) + a PM material (SI fungicide, sulfur, JMS Stylet Oil, Nutrol). Choose PM material based on previously-discussed characteristics and cost.

Immediate Prebloom (or very early bloom). A critical time for PM, BR, DM, and Ph (rachis and fruit infections). A good time to use a strobilurin on PM susceptible varieties. This and the first postbloom spray are the most critical sprays of the season--DON'T CHEAT ON MATERIALS, RATE, OR COVERAGE! Option A: Abound, Sovran, or Flint (PM, BR, some Ph; also, variable DM [Abound, excellent; Sovran, fair to good; Flint, poor to fair]. The best choice if SIs have been used for a number of years against PM, particularly if multiple disease control is needed. Should provide some Botrytis control if a wet bloom period. Option B: Either Nova, Elite, or Rubigan PLUS mancozeb (PM, BR, Ph, DM). Nova and Elite are the biggest guns against BR, so might be the best choice if pressure is high and BR control is more important than PM. Nova and Elite provide postinfection activity against BR, so would be first choice if significant unprotected infection periods occurred within the previous week. Rubigan is (was?) cheaper that Nova or Elite, but doesn't provide nearly the same BR control; however, mancozeb should be adequate if postinfection control isn't required. Option C: Mancozeb + sulfur (PM, BR, Ph, DM). Cheap and reasonably effective but not the strongest choice at a time when the strongest choice is most justified.

Bloom. Vangard or Elevate for Botrytis control may be beneficial in certain years, particularly in problem blocks if weather is persistently wet. Abound, Sovran, or Flint applied recently may be adequate.

First postbloom. (10-14 days after immediate prebloom spray). Still in the most critical period for PM, BR, DM, and Ph (rachis and fruit). Same considerations and options as detailed under IMMEDIATE PREBLOOM. Juice grape growers can substitute Ziram (very good BR and

Ph, only fair DM) for mancozeb if necessary.

Second postbloom. BR control still may be needed under wet conditions and a spray is strongly recommended if infections are evident on the vine. Fruit are less susceptible to PM now, but vinifera varieties (and susceptible hybrids?) still need PM protection, particularly on varieties susceptible to Botrytis. Rachises and foliage remain susceptible to PM. Avoid SI fungicides if more than a little PM is easily visible. Ph danger is mostly over unless very wet. Primary DM should be over, but continued protection may be needed on susceptible varieties if weather is wet, especially if disease already is established (look and see) Option A: Abound, Sovran, or Flint (PM, BR, some Ph; also, variable DM [Abound, excellent; Sovran, fair to good; Flint, poor to fair]. Provides good residual control of the listed diseases if used now. May provide some Botrytis control as bunch closure approaches. Option B: Nova or Elite (BR, PM) + captan or mancozeb (66-day preharvest restriction) if DM and Ph control are needed. Option C: Rubigan (PM) + either (a) mancozeb (if more than 66 days before harvest) for BR, DM, and Ph; or (b) captan (DM, Ph, some BR); or (c) ziram (BR, Ph, some DM). Option D: Sulfur (PM) + either (a) mancozeb (if still allowed) or (b) captan. In most years, lessening disease pressure makes this economical option increasingly practical as the season progresses. Option D: Copper + lime (PM, DM). Adequate for Concords, not enough PM control for vinifera and susceptible hybrid varieties.

Additional summer sprays. Check the vineyard regularly to see what's needed, the main issues will be PM and DM. On vinifera and other cultivars requiring continued PM control, use sulfur as an economical choice to maintain control; SIs and strobilurins are options if they haven't been overused earlier AND little disease is evident. Both provide the advantage of longer residual activity than sulfur, especially in wet weather. For DM, copper + lime or captan are economical standards; Abound is a viable option if general disease pressure or other conveniences justify its cost; Ridomil can be used in case of emergency. BR should not be an issue after the second postbloom spray, except in unusual circumstances (disease is established in the clusters, wet weather is forecast, and it's possible to direct sprays onto the clusters). Ph should not be an issue. See previous discussion for Botrytis at bunch closing, veraison, and preharvest.

FRUIT QUALITY - IMPORTANCE OF FRUIT QUALITY ON WINE QUALITY

Jim Gallander
Horticulture & Crop Science
The Ohio State University/OARDC
Wooster, OH

Fruit quality is influenced by three (3) very important factors: grape variety, fruit condition and grape maturity. Considerable attention must be given to each in order to produce a high quality wine.

Grape Variety

The first prerequisite in making highly acceptable wines is the selection of the correct grape variety. Throughout the many famous wine regions of the world, a single variety is often the critical factor in producing exceptional wines. For this reason, the evaluation of grape varieties for wines has been emphasized at OSU/OARDC. The results from these studies have indicated that several varieties are desirable for making wine in Ohio. These include: Seyval, Vidal blanc, Chancellor, Chambourcin, W. Riesling and Cabernet franc.

Fruit Condition - Rot

Although wine quality is greatly influenced by variety, emphasis should also be given to fruit condition. It is very rare that unsound fruit will yield high quality wines. This is only true for *Botrytis* infected grapes from a few wine areas in certain years. However, more often than not, *Botrytis* infected grapes causes problem wines.

- ~ Produces an enzyme called laccase which causes browning and oxidation.
- ~ Increases the level of glucan which makes the wine hard to filter.
- ~ Damages the fruit which leads to secondary spoilage and causes off-odors and undesirable tastes.

Studies concerning the effect of *Botrytis* rot on wine quality have shown the importance of using sound fruit for wines. Wagener (3) reported that grapes containing 10% *Botrytis* rot should be processed within 1 hour after harvesting. For grapes held over 1 hour, he recommended that the percentage of rot must not exceed 5% to obtain the highest wine quality. Results from Loinger et al. (1) also indicated that wine quality decreased with higher levels of *Botrytis* rot. At a range between 5 to10%, wine quality was significantly reduced as judged by a taste panel. In addition, a study by Ought and Berg (2) showed that wines made from powdery mildew grapes were lower in quality.

Fruit Condition - Holding Times and Temperatures

Also, fruit condition may refer to harvesting temperature and holding time between harvest and vinification. Most winemakers agree that low fruit temperatures are necessary for making high quality wines. This is especially important for vilifying white wines which are considered more delicate in aroma and taste than red wines. For this reason, some wineries require that their grapes be harvested at night or early in the morning. Wagener (3) reported that harvesting temperature had a significant negative effect on wine quality for a short holding time, 1 hour. Grapes held over 1 hour at 80°F yielded wines with lower quality. At a holding time of 18 hours, grapes at harvesting temperatures of 62°F and 80°F produced wines which were judged as poor quality.

Fruit Maturity and Wine Quality

After selecting the correct grape variety with good fruit condition, the next important factor to consider in making high quality wines is harvesting the fruit at peak maturity. In cool regions, such as Ohio, the usual criterion for picking grapes is measuring the sugar content (°Brix) of the grapes. Although the general concept is that the best wines are made from the highest °Brix grapes, studies in Ohio have found that this is not necessarily true.

The results of the sensory evaluation indicated that some varietal wines were preferred from grapes at the mid-maturity stage. For example, wines from Vidal blanc, Catawba, and Niagara were rated best in overall quality at °Brix readings about 19.0°, 19.9°, and 14.0°, respectively.

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ECONOMICS OF VINEYARDS ESTABLISHMENT

Ron Barrett
Kinkead Ridge Vineyard and Winery
Ripley, Ohio

Observations

- Global trade in wine is increasing and small regional wineries are beginning to feel the pinch.
- The trend for some time has been toward dry, red and premium wines, and away from sweet white jug wine.
- We are headed for a generic grape glut.
- Price points for fighting varietal ($6 to $9) wines are contracting, indicating that we are on the verge of a general softness in wine pricing.
- Producers in areas where it is possible to grow vinifera are doing so and with few exceptions are increasingly avoiding both hybrids and native varieties.
- Wine writers and the consuming public are so biased against even well made hybrid wine that no amount of persuasion can change their perception.
- Internationally recognized varieties which make the best wine in a given region tend to define and ultimately dominate perceptions of wine from that region.

Conclusions

- More than at any time in the recent past, potential growers need to carefully assess market trends so as to not be left with unprofitable or unsaleable grapes.
- Potential growers of American or Hybrid varieties should not plant unless their plans include either full or part ownership of a winery dedicated to the processing of their grapes.
- Vinifera almost always makes better wine, is usually more profitable, and is more likely to be in demand in the future.
- Profit potential will be maximized by selecting a vinifera variety which best matches long-term market demand and cultural characteristics with site specific conditions.
- Ohio wineries need to identify signature vinifera varieties which produce distinctive regional wines, promote them, price them adequately and reward growers for producing superior wine grapes

Summary

If possible, **plant vinifera** and concentrate on varieties which make the best wine in your local climate, while considering future market demand and cultural characteristics.

COST OF CONSTRUCTING A DEER FENCE

Ron Barrett
Kinkead Ridge Vineyard and Winery - Ripley, Ohio

6' 3" Fence: **4-5" x 9' posts** **woven wire with 12" stays** **Posts 33" in ground**	**Top Barb Wire at 75"** **Second Barb Wire at 70"** **Woven Wire 4" to 65"** **Bottom Barb at 2"** **About $1.25/ft. plus gates and gate posts**

7' Fence: **4-5" x 10' posts** **woven wire with 12" stays** **Posts 36" in ground**	**Top Barb Wire at 84"** **Second Barb not needed** **Woven Wire 4" to 79"** **Bottom Barb at 2"** **About $1.35/ft. plus gates and gate posts**

Materials cost: $2500 to $3500 for 5 acres including headlands depending on aspect and layout.

Misc. needed: Wire stretcher ($140), Crimping tool ($50),
HD-8 post driver 6=3@ ($2000) or HD-10 post driver 7= (est. $3000)

Post supplier: Panhandle Forest Products (Idaho): (208) 263-4603
Fencing Supplier: Kencove Farm Fence (Pennsylvania):
1-800-536-2683, www.kencove.com

VINEYARD ECONOMICS

Mark Nissel
Painter Fork Vineyard
Bethel, OH

Recommended Varieties

Variety selection based on the following
Is its growth characteristics compatible with you site?
Is the variety desired by wineries?
Does the variety sell for enough to make it economical to grow?
Does the variety produce sellable fruit in bad years?

Some of My Recommended Varieties

French-American Hybrids
Seyval
Vidal
Chambourcin
Chancellor
Dechaunac
Chardonnel

Vinifera - site specific
Chardonnay*
Cabernet Franc
Cabernet Sauvignon
Many others to try

Is its growth characteristics compatible with you site?

Is you site well drained?
Does your site have good air drainage?
What is you location to the surrounding area?
Do you usually get a late spring or early fall frost?
Is the variety an early or late budding one?
Is the variety an early or late maturing one?

Is the variety desired by wineries?

What is the market for you grapes?
How many tons do the local wineries need?
Will they contract for the grapes?
Can you haul or arrange for shipping if not local?

Is the variety economical to grow?

How much does it cost to grow the grapes?
How many tons can you expect to harvest per year?
What price will they sell for?
How many harvest will be lost due to weather?

Varieties Not Recommended for Southern Ohio

All American varieties
Foch
Aurore
Vinifera
Riesling?
Pinot Noir?
Sauvignon Blanc
Anything high Botrytis susceptibility

Vineyard Economics

Cost are related to vine spacing
Low vine density leads to lower cost and possibly lower wine quality (10x8)
Higher vine density increases costs and can increase wine quality (7x5)
Hybrids do not change in price significantly so lower density is recommended
Vinifera grapevines have much higher cultural costs
Vinifera if grow well will get 2 to 4 times the price per ton as hybrids.
Yields of well grown vinifera range from 1.5 to 6 tons per acre.
Yields of hybrids range from 3 to 7 tons per acre.

Vineyard Economics

Establishment Costs per Acre for a (10x8) Hybrid vineyard
200 line Posts @ $4.00 = $800
20 end Posts @ $12.00 = $240
Wire, springs, earth anchors, wire tightners for a 3 wire trellis $750
560 vines and stakes @ $2.50 = $1400
Total is $3190 Plus 120 hours of labor

Vineyard Economics

Additional costs
Equipment rental or use
Buying special use equipment, for planting, post driving, sprayers, tractors, management sprays $160 - $300 per acre per year
Cover crops

Picking supplies and lugs or bins
Finding a buyer

Vineyard Economics

It will take 3-4 years to get your vineyard into production.
It will cost approximately $7500 - $9000 per acre for hybrids plus equipment
It will cost approximately $10,000 to $15,000 per acre for vinifera, In California they are spending $25,000 and more per acre

Vineyard Economics

Equipment costs range from $5000 to $40,000
Sprayers run from $2000 to $6000 for small sprayers
Narrow Tractor 30 horse power minimum $16,000 - $25,000
Mower $700 - $3000
Rototiller $1000
Auger $750

Post driver
Hand tools $1500
Picking lugs or bins $2000 - $3000
Trailer to transport $1500

Vineyard Economics

Cost recovery for establishing a vineyard are 7 - 10 years for a hybrid vineyard
Costs recovery for establishing a vineyard are 5 - 10 years for a vinifera vineyard
Vines take 4-6 years to fully mature and produce a full crop.
First crop is a half crop in the 3rd year

Vine Grants

Pays for the cost of the vines
Must contract the yield with a bonded Ohio winery for 5 years
Must plant at least 1 acre of each variety
Accelerates the payback time for a vineyard
Makes sure you plant a crop that is needed
Helps with cash flow since there is no crop in the second year.

[Editor Note: Vine Grant program is no longer operational]

WHAT DOES IT COST TO ESTABLISH A GRAPE VINEYARD?

Nicholas Ferrante
Ferrante Winery & Vineyards
Geneva, Ohio

A. Land Preparation

1. Leveling - D-8 Bulldozers - 10,000 ÷ 6 acres = $1,666.00 per acre

2. Drainage Tiling - 8.5' row spacing with 4" row draining to 6" mains
   Materials - $ 7,500.00
   Labor - $ 11,600.00
   Total - $ 19,100.00 ÷ 6 acres = $3,183.00 per acre

3. Fall Land Preparation - Leveling, plowing discing, subsoiling and spike drag
   $ 1,500.00 ÷ 6 acres = $ 250.00 per acre

4. Fertilizer - Potash, borate and zinc - $ 271.00 ÷ by 6 acres = $ 45.17 per acre

5. Ag Lime (Bulk) $ 596.78 ÷ 6 acres = $ 99.46 per acre

6. Spring Land Preparation Cultivate and cultipack
   $ 400.00 ÷ 6 acres = $ 66.67 per acre

7. Soil Sampling/Consultation
   $ 100.00 ÷ 6 acres = $ 16.67 per acre

Total Land Preparation per acre = $ 5,326.97

B. Vines and Planting

1. 2,250 Riesling, Clone 239, Rootstock So4 and 3309

2. 2,250 Cabernet Franc, Clone 214, Rootstock SO4 and 3309

3. 2,250 Vidal on So4

4. 1,125 vines planted per acre

Cost per vine = $ 2.75
Total cost of vines = $ 18,565.00
Cost per acre = $3, 094.17

5. Planting was done by making a ditch with a V-plow and hand planting each vine

6. Replacement vines $ 400.00 ÷ 6 = $ 66.67 per acre

7. Total cost per acre $3,493.84

Vines were planted at 5 foot spacings and did not vary by cultivar

C. Trellis Construction

1. Vinifera (Cabernet Franc, Riesling) - Low wire cordon (32" fruiting wire) with 3 sets of catch wires
2. Hybrid (Vidal) - Top wire cordon and 40" bottom wire cordon (Scott Henry) with middle catch wires (1 set)

3. Trellis Costs

		Each	Total
1,800	9' metal posts	$2.95	$ 5,310.00
130	8' Cedar End Posts	4.90	637.00
7,000	4' Metal Staking Rods	.22	1,540.00
20 Rolls	11 gauge wire (crimped)	49.30	986.00
50 Rolls	12.5 gauge wire	42.36	2,118.00
15 Rolls	9 gauge wire	59.00	885.00
130	Anchors	6.50	845.00
260	Large Gripples	1.55	403.00
360	Small Gripples	1.05	378.00
3,600	JR Clips	.16	576.00
1,800	Wire Clips (crimped)	.05	90.00
	Freight Charges		500.00
	Total Costs		$14,268.00
	Cost Per Acre (materials)		$ 2,378.00
	Labor (Estimate) $ 4,800.00		
	Labor Per Acre		600.00
	Total Cost of Trellis Construction		$ 19,068.00
	Total Cost Per Acre		$ 3,178.00

D. Weed Control and Hilling of Graft Unions

1st year

- Very little weed pressure, no herbicides used
- Hand hoeing was implemented a few times throughout the growing season
- The graft unions were covered by use of a Braun Hydraulic grape hoe

E. Row Middle

- Cultivation (disc and Braun Cultivator (vario)

- Rye cover crop, seeded in June

F. Other

Gravel pocket drains over tile lines in areas that were slower to drain. Dug out an area of 4' long by 2' wide down to tile line and filled open area with pea gravel

G. Consulting Fees - International Viticulture

$ 2,000.00 for first growing season. Cost per acre $ 333.00

Total Cost to Establish Vineyard per Acre

Land Preparation	$ 5,326.97
Vines and Plantings	3,493.84
Trellis (materials & labor)	3,178.00
Consultation	333.00
Total Costs	$12,331.81

EXPERIENCE WITH NEW CULTIVARS IN OHIO

Todd Steiner, Dave Ferree, Jim Gallander and Dave Scurlock
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Ohio State has exerted considerable effort over the years on evaluating new cultivars for their potential to make high quality wines when grown in our environment. A number of the wineries would like to identify a significant grape for our area and have assisted in selecting cultivars for us to evaluate. The following are several cultivars that have received our research focus in recent years.

Pinot Gris

This grape has performed well and resulted in high quality wine in several of the cooler, humid growing areas such as Oregon. Pinot Gris is a pink-gray variant between Pinot noir and Pinot Blanc. Pinot Gris has moderate vigor and has been productive in early years in our trials (Figure 1). We have typically removed clusters from shoots less than a foot long. The cluster is tight and bunch rot can be a problem, particularly on vigorous sites. Leaf removal has reduced rot and we have investigated gibberellin sprays to elongate the rachis that have also reduced bunch rot in problem years. It is sensitive to powdery mildew. Early results from our training system trials indicate that the split canopy Scott Henry system or pendlebogan appear promising. The fan system with many trunks has produced a very dense canopy and increased bunch rot in years where fall is rainy. Pinot Gris is harvested early usually around mid-September and generally reaches optimum maturity under our conditions. It is not as hardy as Riesling, and vines should be trained with multiple trunks and hilled up over the graft union as some protection against winter freeze damage. In other experiments we are evaluating vine spacing, clones and means of reducing bunch rot.

Pinot Gris makes a full bodied white wine and is adaptable to several wine making styles. Pinot Gris can be fruity in character with the use of stainless steel fermentation at cool temperatures. Temperatures form 55°F to 63°F are ideal conditions for bringing out the fruity characteristics of this variety. There would be minimal lees contact and no oak aging with this style. The second wine making practice would utilize a stainless steel fermentation with extended lees contact. Extended lees contact after fermentation could be implemented upwards to six months as long as sulfur dioxide levels are monitored correctly. This style would increase the body and mouth feel bringing forth a wine more complex in character. A third style would utilized barrel fermentation and aging. The use of a malolactic fermentation can be implemented with the extended sir-lie contact of the barrel fermentation. If a malolactic fermentation is to be carried out, it would be advisable to have the titratable acidity between 8.1 to 8.5 g/l before starting. This will account for the drop in titratable acidity due to malolactic fermentation.

We have conducted several studies to identify techniques that could improve quality of

Pinot Gris wine. In a study evaluating various times of skin contact: 0, 2, 6 and 24 hours, we found that 6 hours stood out as having the highest sensory scores for aroma, fruitiness and complexity, as well as taste in fruitiness and complexity (Figure 1). Sensory evaluation from wines made with addition of 0, 25, 50 or 100 ppm sulfur dioxide to the must found that wines with 50 ppm sulfur dioxide had the highest scores in all categories. Other enology studies currently in progress with Pinot Gris are 1) evaluating wine quality at three different harvest maturity levels. The three different maturity levels being looked at for wine quality in relation to harvest time are 19°, 21°, and 23° Brix. 2) The comparison of various lactic acid bacteria strains and their influence on wine quality.

Chambourcin

In a survey of Ohio wineries, Chambourcin was identified as the red French-American hybrid with the most promise. It is a relatively late maturing variety with large, long cylindrical clusters of loosely held berries. Chambourcin is very productive on vines of moderate vigor. Because of its late ripening and tendency to over-produce, cluster thinning is a requirement to achieve optimum maturity for high quality wine and to lessen winter hardiness problems. Chambourcin is not as hardy as some of the other French-American hybrids and likely similar in hardiness to the most hardy vinifera cultivars. Our studies have shown that Chambourcin is sensitive to low light conditions around bloom, which can reduce fruit set. We currently have studies in place evaluating the following for their influence on Chambourcin: chemical bloom thinning, training systems, rootstocks, and crop load.

Chambourcin can be used in making a high quality varietal red wine, as well as an excellent tool for blending. In our experience, Chambourcin is a variety that can develop sugars upwards toward 22-23°Brix (depending on the harvest year), while retaining a relatively low pH. Since we are in a cool climate, Chambourcin can possess a slightly high TA from 9.0 to 10.0 g/l. Chambourcin can achieve excellent color extraction by paying attention to fermentation temperatures of 80-85°F and adding commercially available macerating pectinase enzymes. The harvest parameters described above make Chambourcin a good varietal for malolactic fermentation. This is also a variety that can benefit from the use of oak supplementing tannin development.

Chambourcin possesses fruit like characters in the nose such as cherries, raspberry and blackberry. As this wine ages, it can develop aromatic compounds of leather and cigar box characteristics. Chambourcin holds promise for our cool climate wineries looking to a high quality red wine with vinifera like characteristics. We are currently evaluating enology studies on Chambourcin looking at crop load and lactic acid bacteria strains on wine quality.

Lemberger

We have limited experience with this cultivar, but have been pleased with its potential thus far. It is a very vigorous vine producing many large clusters that are loose and bunch rot has not been a problem. It ripens in mid-October and generally has reached optimum maturity. We have

not had any test winters, but reports from New York and Michigan indicate that hardiness may be equal to some of the most hardy vinifera. On a high vigor site, a size reducing rootstock should be used. A bilateral cane pruned system appears to work well. Thus far, we have had no disease or insect problems with a conventional spray program.

Lemberger otherwise known as Kekfrancos in Hungary, Blaufrankisch in Austria, Limberger/Lemberger in Germany has also developed a sound reputation in Washington. This grape variety of "disputed" origin derived from *Vitis vinifera* exhibits some great potential for a quality red wine in our region. Our brief experience with this variety has shown us harvest parameter sugar concentrations around 22°Brix, with a titratable acidity of 9.0 g/l and a relatively low pH of 3.2 to 3.3. We have experienced a dark reddish-purple color extraction during fermentation with temperatures at 80-85°F utilizing commercially available macerating pectinase enzymes. As a young wine, Lemberger is very fruity and sightly herbaceous. With the use of a malolactic fermentation and aging in oak, it becomes more complex, full in body with acceptable tannins. Lemberger may develop sensory characteristics of chocolate and smoke with aging. In our research at OARDC we are currently looking at the effect of pressing times in relation to °Brix and use of different lactic acid bacteria strains on wine quality.

Dornfelder

Dornfelder was developed in Germany from a cross of Heifensteiner x Heroldrebe. The vine has a vigorous trailing habit. It develops large loose clusters with large berries and little problem with bunch rot. It is very productive (5-6 tons/acre) and tends to overcropping and may need cluster thinning in addition to pruning to adequately balance growth and cropping. It matures before 'Lemberger' and 'Cabernet Franc'. It is moderately susceptible to mildew. Unfortunately, it is on the lower end of the hardiness scale, probably similar to 'Merlot'. As a result of this we have had considerable problem with crown gall. Thus, although the wine quality is good, its lack of winter hardiness would make it unsuitable for most sites in Ohio.

Dornfelder is increasingly appreciated as one of the most successful German red wine crosses. OARDC harvest of this particular variety exhibits excellent color extraction from skins during fermentation carried out at temperature of 32.2°C (90°F) to 35°C (95°F). Parameters would indicate a harvest of 20°Brix with a titratable acidity of 8.0 g/L and a pH of 3.40. The color extraction of Dornfelder has been reported by some as being 'inky" in color. Dornfelder is full-bodied, velvety texture with attractive aromatic fruit. Enology style can be fruity with a hint of sweetness or benefit from the use of oak and aging to provide deeper tannin development. This variety shows excellent potential for aging in the bottle. Dornfelder with its quality potential is usually sold as a varietal rather than blended. The versatility of Dornfelder can develop this as an early drinking, fruity aromatic red wine or for cellaring oak aged bottles.

Chardonel

Chardonel was developed in 1990 by the New York Agricultural Experiment Station from a

cross of 'Seyval' and 'Chardonnay' (formerly NY-45010 and GW-9). It matures midseason after 'Seyval' in moderate size, loose clusters. Unlike 'Seyval' it requires no cluster thinning to maintain vine vigor. High quality wines can be made from yields in the range of 4-6 tons per acre. It is slightly less winter hardy than 'Seyval' and likely similar in hardiness to 'Vidal'. It is reported to be susceptible to crown gall and root borer.

Our brief experience with Chardonel shows us harvest parameters upwards to 23°Brix and with a titratable acidity of 9.0 g/L and a relatively low pH of 3.2 . This variety exhibits a pleasant fruitiness with good body and an excellent varietal character. Chardonel exhibits little French American hybrid sensory characteristics. Higher quality wines have been reported as expressing Chardonnay-like characteristics where lower quality wines have been associated with Seyval characteristics. Chardonel is versatile in its winemaking style. This variety can be made fruity in style with the use of a stainless steel fermentation. Chardonel may also benefit in body and complexity from extended less contact, the light use of oak or a malolactic fermentation.

Traminette

Although our experience is limited, we have been impressed with the initial wine quality and vineyard performance of this cultivar. Traminette is a late-mid-season (late-September) white wine grape with Gewurztraminer varietal character, but hardier than the parent cultivar. It is productive with moderately loose clusters. In New York Traminette vines are reported to be moderately winter hardy, similar to Vidal with good bud hardiness, while trunk injury is occasionally a problem especially on heavier soils. Foliage and fruit are reported to be moderately resistant to powdery mildew, particularly late in the season, black rot and bunch rot. Foliage is susceptible to downy mildew. Although leaves stay green late, cane periderm forms early with good wood maturation. Traminette expresses distinctive spicy and fragrant aromas much like its Gewurztraminer parent. This variety exhibits excellent balance between pH, sugar and acidity. Traminette can accumulate a significant level of sugar, while maintaining good acidity and a relatively low pH. Preliminary studies at OARDC would indicate that skin contact between fermentation at 4°C (12-24 hours) will enhance the spicy floral aromatic compounds. This wine can be fermented dry to semi-dry expressing a wine with good body and Gewurztraminer-like character.

We are currently evaluating a range of cultivars at Kingsville, Wooster and Ripley to test their adaptability to the various climatic conditions existing in Ohio. An important aspect of this work is not only evaluating the viticultural characteristics and potential, but also their adaptability and potential for enological properties important in the winery.

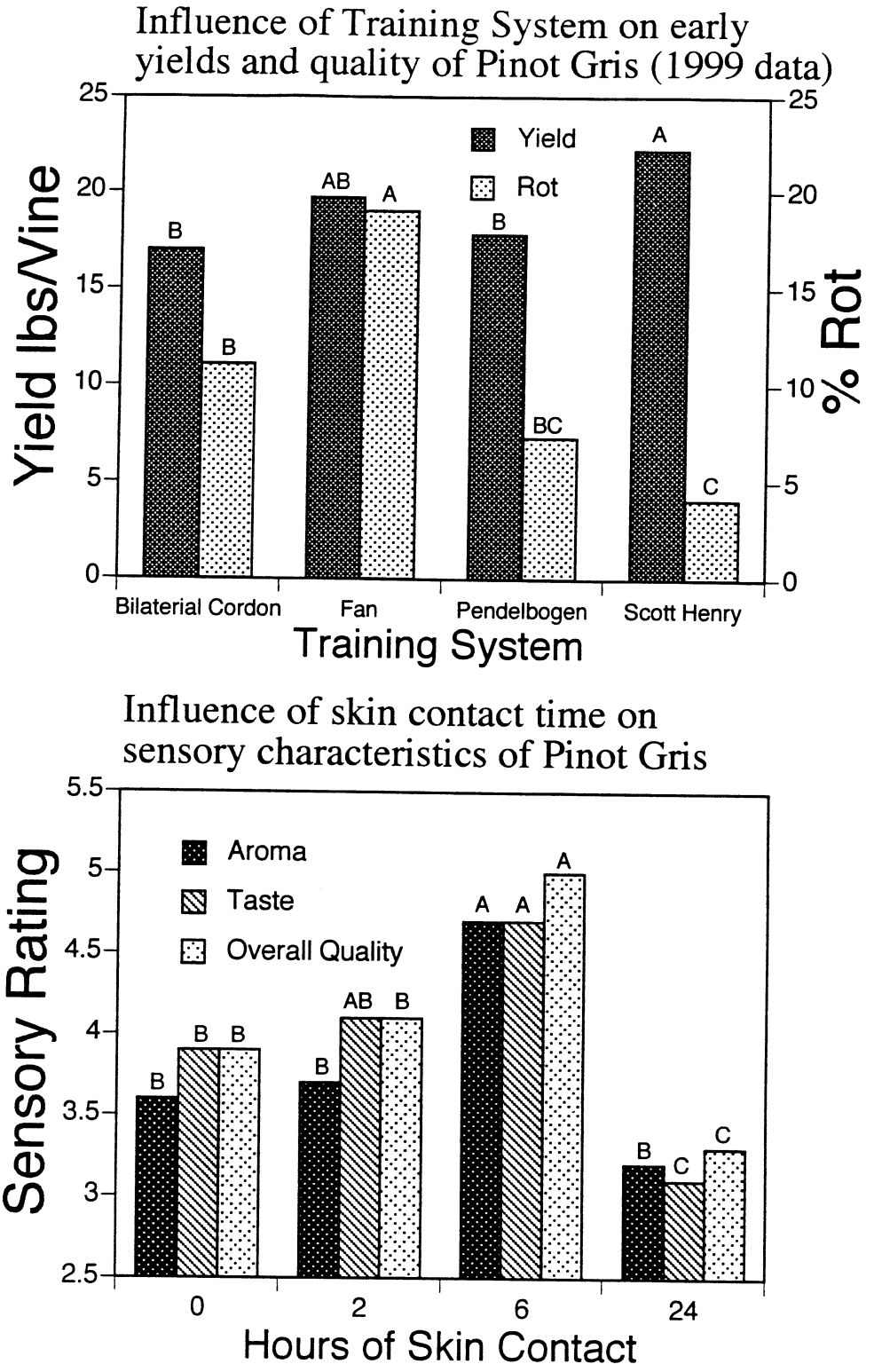

Figure 1. Influence of training system and skin contact time on Pinot Gris in Ohio.

M-L FERMENTATION— THE USE OF MALO-LACTIC FERMENTATION IN WINES

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Malo-lactic fermentation (MLF) refers to the conversion of malic acid to lactic acid and carbon dioxide by certain lactic acid bacteria. This secondary fermentation occurs after the alcoholic fermentation and usually effects the character and quality of wines.

Effects of MLF

The first immediate effect of malo-lactic fermentation in wine is deacidification. Since lactic acid is a chemically weaker acid, and less tart, than malic acid, malo-lactic fermentation reduces wine acidity by decreasing titratable acidity and increasing pH. The second effect of ML fermentation is bacteriological stability. A complete ML fermentation will deplete L-malic acid in a wine. Thus, these bacteria are not able to grow and cause spoilage after bottling. The third effect is flavor complexity. Malo-lactic bacteria produce some flavor compounds such a diacetyl and acetoin. At their threshold levels, these two compounds may add subtle complexity to wine flavor. However, ML fermentation is considered undesirable in some delicate and light varietal wines. The reason is that high levels of lactic acid tend to mask the fruity character of these wines. On the other hand, many winemakers believe ML fermentation is desirable in making high quality red wines. Another effect is the increase in pH which generally occurs following ML fermentation. If the pH increases to about 3.5, the precipitation of potassium bitartrate will occur in the wine. This loss in tartrate will result in a slight additional deacidification (1). Also, in red wines loss in color intensity will occur as the pH increases.

Although ML-fermentation can offer advantages, initiation of bacterial deacidification is often difficult. Research pertaining to MLF indicated that several factors affect the stimulation of this fermentation in wines.

Factors Influencing MLF

Among the factors affecting Ml fermentation, pH has a major influence. According to Kunkee (2), the critical pH for ML fermentation is around 3.3. Above pH 3.3, ML fermentation is more likely to occur. Below pH 3.3, special effort is needed to initiate this secondary fermentation, such as, adjusting the sulfur dioxide addition and increasing the cellar temperature.

The pH not only affects the development of malo-lactic bacteria, but also influences the antiseptic action of sulfur dioxide. As the pH decreases below 4.0, the concentration of sulfurous acid increases; therefore, more antiseptic activity and less incidence of ML fermentation. Therefore, to encourage ML fermentation, the level of sulfur dioxide should be kept to minimum,

usually less than 50 ppm at the time of crushing.

Another critical factor to stimulate ML fermentation is to maintain proper cellar temperatures. The most favorable temperatures for ML fermentation range between 65°F to 75°F. Low temperatures usually favors the growth of *Leuconostoc* bacteria, not *Lactobacillus* or *Pediococcus*. The occurrence of ML fermentation is also influenced by the alcohol content in the wines. High alcohol contents in dessert wines usually inhibit ML fermentation. The alcohol content of the table wines only delays bacterial fermentation.

In general, three types of lactic acid bacteria are found in musts and wines. These include Pediococcus, Lactobacillus, and Leuconostoc with the former being the most desirable. To rely on a natural ML fermentation, without bacterial inoculation, is usually not a good practice. Today, several commercial starter cultures are available to winemakers. A few companies that offer ML cultures are listed below:

Suppliers:

Scott Laboratories
PO Box 4559
Petaluma, CA 94954-5687
Tel: 707-838-6312

The Wine Lab
477 Walnut St.
Napa, CA 94559
Tel: 707-224-7903

Vinquiry
7795 Bell Rd.
Windsor, CA 95492-8519
Tel: 707-838-6312

Presque Isle Wine Cellars
9440 W. Main Rd. (US Rt.20)
North East, PA 16428

For the past several seasons, studies at OSU/OARDC included the evaluation of commercial ML cultures for wine quality. These tests indicated that certain strains were suitable for initiating ML fermentation and producing acceptable wine quality. They included: OSU, EQ54, Endoferm D and Vinoflora oenos. When using commercial cultures, winemakers should carefully follow the manufacturers' directions in preparing and inoculating the cultures in wines.

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INFLUENCE OF CROP LOAD ON CHARDONNAY GRAPE QUALITY AND VINE COLD HARDINESS

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Introduction:

The negative consequences of excessive crop levels on grape and wine quality have been appreciated for many years, yet the definition of a specific crop level associated with optimal fruit/wine quality is elusive; it is affected by cultivar, environmental conditions, and cultural practices. Optimal yields therefore vary by viticultural region and convention. "Overcropping" can be defined as an insufficient leaf area/fruit weight ratio. Generally, the leaf area per fruit weight ratio below which fruit sugar accumulation is measurably retarded is 7 to 10 $cm^2 \cdot g^{-1}$. Cane pruning weights correlate with leaf area, and both are known to determine vine capacity. Therefore, the use of a crop yield/cane pruning weight ratio (defined by some as "crop load") follows the same logic as leaf area/fruit yield, and is easier for growers to evaluate. A summary of published reports would support a generalization that the relationship between crop level and grape and wine quality is not necessarily linear: optimal grape and wine quality are typically obtained from low to moderate crop levels, above which quality sharply decreases with excessive crop yields. The optimal quality portion of such a response curve would be fairly broad. That is, we would expect to see very small changes in grape (and wine) quality across a fairly wide range of leaf areas or cane pruning weights, at least in suitable environments with vines subjected to excellent vineyard management. In addition to the direct effects on crop maturation, crop level affects canopy density via shoot vigor through competition for photo-assimilates. Shoot length, leaf size, cluster weight and berry weight decrease as crop loads increase. Aside from the immediate effects of overcropping on fruit quality, grossly overcropped vines are subject to increased winter injury; however, the effects of more moderate crop levels, or leaf area to crop ratios, on vine tissue hardiness are less obvious.

Crop level studies were initiated at Virginia Tech in 1995 to provide basic guidelines as to what were tolerable (optimal) crop levels with Chardonnay and Cabernet Sauvignon under northern Virginia growing conditions. The research has been conducted at the AHS AREC in Winchester, VA. Some of our preliminary results with Chardonnay are discussed here.

Objectives:

To evaluate the long-term impact (sustainability) of different crop levels on vine capacity (the quantitative ability of the vine to produce crop and vegetation)

To quantify the influence of crop level on dormant bud and cane cold hardiness

To define and quantify relationships between grape crop level, the concentration of aroma and flavor precursors, and wine quality (this objective pursued by Dr. Bruce Zoecklein, at Virginia Tech's Department of Food Science and Technology.

Materials and Methods:

Chardonnay crop levels: Three crop levels, approximately 4, 7, and 10 tons/acre , were established on mature Chardonnay vines trained to an open lyre divided canopy training system at Winchester in 1995. The experimental design was a completely randomized design and consisted of six three-vine replicates per crop level. Treatments have been applied to the same plots each year to evaluate long-term responses. From 1995 to 1999, inclusive, the vines were cordon-trained and spur-pruned. Starting with the 2000 season, an additional factor of pruning type was added, with the addition of cane-pruned vines. We added cane pruning because we noted a reduction in clusters per shoot with the high-cropped, spur-pruned vines.

Vine and vineyard management was typical for the mid-Atlantic. Shoots were positioned with the aid of foliage catch wires, a few leaves per shoot were pulled from around fruit clusters to improve disease control, and shoot tops were hedged as needed to retain approximately 17 nodes per shoot. Disease and insect control was good. Measures of canopy density included measures of actual leaf area, point quadrant (canopy transects) analyses, and measures of canopy light penetration.

Repeated berry sampling, final fruit harvest, measures of wood maturation, and measures of bud and cane cold hardiness were all done in order to understand the impact of crop level on fruit and vine performance. Small lots of wine have been made and evaluated under the direction of Dr. Zoecklein.

Results:

Our target crop levels were generally well met in 1995, but have deviated since (Figure 1), particularly in 1998 and 1999. In 1996 we saw some evidence of yield compensation on the high crop vines as evidenced by lower cluster weights compared to the low or moderate crop levels (Table 1). The lower cluster weights were due to fewer berries per cluster. Exposure to -5°C on 10 April 1997, with buds ranging from full swell to 2" shoot growth, reduced the highest crop potential in that season. The subsequent inability to attain greater than 7 tons per acre in 1998 and 1999 was taken as evidence of yield compensation, with the clusters/shoot and cluster weight being the components most notably affected (Table 2). An upward yield compensation has also occurred with the "low" treatment, with increased cluster weight and clusters/vine. This has limited our ability to effectively restrict the low crop. Canopy measures of light penetration (PAR) and point quadrant analyses illustrated that canopies of all crop level treatments had acceptable dimensions of leaf layers and percent fruit exposure . There has been no evidence of vine size reduction (cane pruning weights) as a function of crop, over the course of this experiment. Cane maturity, which is one indicator of vine carbohydrate reserves, has been assessed each fall. The percentage of mature nodes per cane – nodes with visibly "ripened" periderm -- has not been affected by crop level, but was somewhat lower at the end of the 1997 season, perhaps as a result of the drier than usual season (data not shown).

The preliminary results of our 2000 growing season have shown actual crops of 11.1 (high), 9.2 (moderate), and 3.8 (low) tons per acre for Chardonnay. While crops were harvested at different dates, the soluble solids concentration at harvest differed only by one degree Brix (data not shown). Pre-harvest and harvest samples are currently being assayed for aroma and flavor precursors.

Cold hardiness: Routine, laboratory measures of dormant bud cold hardiness showed that the highest crop level of Chardonnay was associated with a slight delay in fall acclimation (Figure 2). Chardonnay buds collected from the highest crop level vines were almost 2°C less hardy than buds collected from either the low- or moderately-cropped vines during the 1995-96 winter. Interestingly, the reductions in cold hardiness of dormant buds were observed without overt differences in the degree of wood maturation. Similar data collected during the 1996-1997 and 1997-1998 dormant periods appear to be consistent with the prior two seasons' data; however, failure to sustain our desired highest crop level prevented our true evaluation of a "high" crop level effect on cold hardiness. While these data are of a preliminary nature, they do suggest that a "penalty" is paid for high crops in the form of reduced fall acclimation rate, especially when the leaf area to crop ratio is below 10 $cm^2 \cdot g^{-1}$ (as in 1995).

To date, the most significant, negative, viticultural impact of the high crops with Chardonnay has been a slight reduction in cold hardiness of dormant buds. This slight reduction in cold hardiness may be tolerable in excellent sites given the increased profit realized by the higher yields.

Grape and wine quality: Chardonnay crop level had a consistent effect on the rate of sugar accumulation with the highest crop level resulting in the lowest °Brix and berry weights at most sampling dates. In 1995, total glycosides per berry and per gram of fresh fruit weight were influenced by treatment at three of five sampling dates (Table 3). Phenol-free glycosides per berry and on a per gram basis were influenced by crop level at two and three sampling dates, respectively. Treatment did not influence the ratio of phenol-free glycosides to total, which in 1995 averaged 66%. At harvest the low and moderate crop load treatments differed in °Brix by 4.5% while the concentration of total glycosides per gram of fresh fruit weight was 32% higher in the low treatment.

Crop level treatment influenced the rate of increase in glycosides. In 1995 and 1996, the rate of increase in total glycosides and phenol-free glycosides was initially greatest in the high, followed by the moderate and finally the low crop level treatments. However, by approximately 20 °Brix the rate of glycoside increase was greater for the low crop treatment and resulted in a higher concentration at the end of the sampling period. At harvest in 1996 and 1997, the low crop had the same °Brix as the moderate crop level treatment, yet a 15.0% and 15.1% higher concentration, respectively, in total glycosides. Phenol-free glycosides averaged 63.7% and 73.5% of the total glycosides in 1996 and 1997, respectively.

Chardonnay wines were produced each season and monitored for the change in glycosides and glycoside fraction concentration during and after fermentation. Fermentation decreased the concentration of total and phenol-free glycosides, and slightly changed the ratio of the two. At dryness, phenol-free glycosides averaged 66% of the total each year. The results of duo-trio sensory analysis of Chardonnay wines produced from the 1995-1997 seasons is provided in Tables 4 and 5, respectively. Maximum differences in crop level generally influenced both aroma and flavor in 1995, but not in 1996.

Must and wine quality results to date suggest that crop level has minor impact on quality at low (e.g., less than 19 °Brix) sample maturity, but that the differences become more meaningful as crop maturity advances, particularly above 21.5 °Brix. This was particularly evident in years with good ripening conditions, such as 1995. Lower crops attained riper fruit more rapidly than did high-cropped vines. When high-cropped vines were allowed to carry crops longer, to ripen those crops to the same SSC, the resulting wines were often inferior to those of lower-cropped vines.

A more in-depth discussion of fruit and wine quality results can be found at: http://www.fst.vt.edu/zoecklein/VVA2000.html

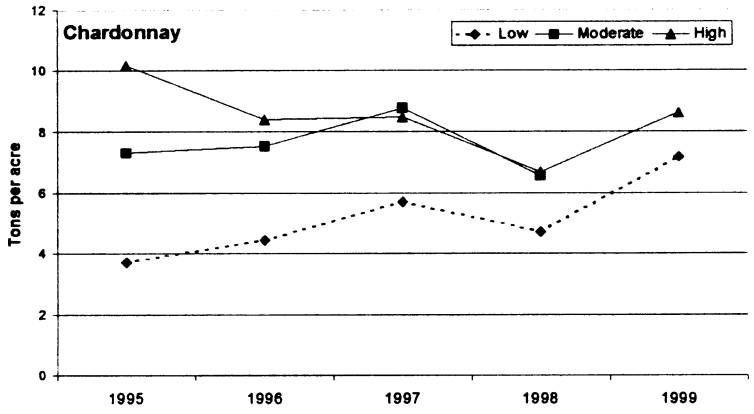
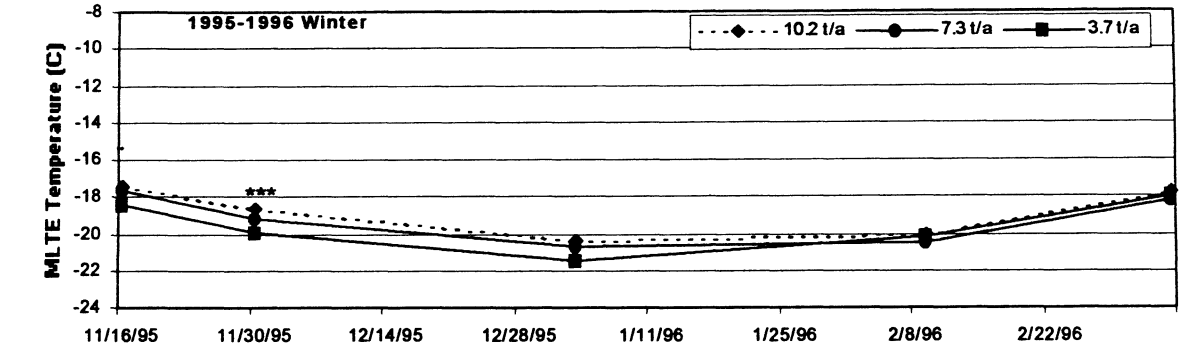
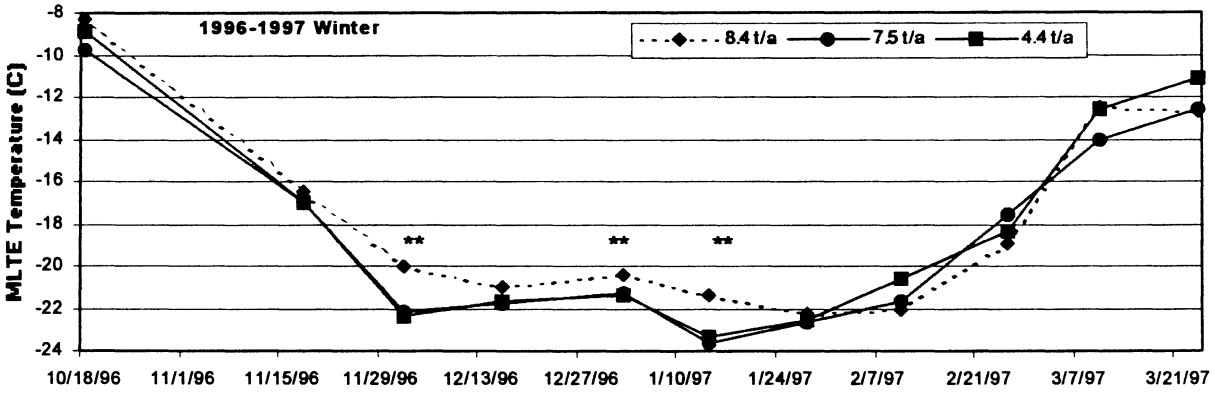


Figure 1. Actual crop levels achieved with Chardonnay where target crop levels of 4 (low), 7 (moderate) and 10 (high) tons per acre were targeted in each of four years. Only the low and high crops were attempted in 1999.





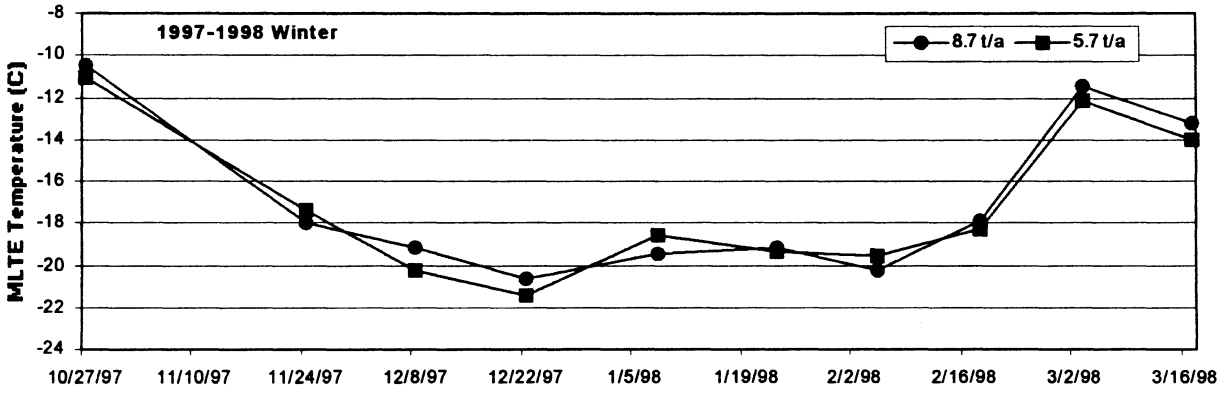


Figure 2. Dormant bud cold hardiness (measured as Mean Low Temperature Exotherm [MLTE] temperature) of Chardonnay as affected by three or two (1997) crop levels over three growing seasons. ** and ***: significant treatment effects at $P \leq 0.01$ or $P \leq 0.001$ level, respectively.

Table 1. Components of yield and canopy characteristics of Chardonnay grapevines as affected by three crop levels during the 1995-1997 growing seasons.

	Relative crop level[y]								
Parameter	**1995**			**1996**			**1997**		
	Low	**Moderate**	**High**	**Low**	**Moderate**	**High**	**Low**	**Moderate**	**High**
Components of yield									
Clusters per vine	27.7 c	56.8 b	84.0 a	44.2 c	78.5 b	115.3 a	50.3 b	83.3 a	83.1 a
Cluster wt. (g)	234.8 a	225.4 ab	210.9 b	176.1 a	168.0 a	127.1 b	197.8 a	183.3 a	177.9 a
Berry wt. (g)	1.55 a	1.61 a	1.55 a	1.65 b	1.65 b	1.73 a	1.88 a	1.81 b	.
Berries per cluster	151.8 a	140.1 a	136.0 a	106.9	102.5	74.0	105.2 a	101.4 a	.
Fruit wt. per vine (kg)	6.5 c	12.8 b	17.8 a	7.8 c	13.2 b	14.7 a	9.9 b	15.3 a	14.8 a
Tons per acre equivalent[z]	***3.7***	***7.3***	***10.2***	***4.4***	***7.5***	***8.4***	***5.7***	***8.7***	***8.5***
Leaf area per fruit wt. (cm^2/g)	18.0 a	9.5 b	7.6 c	18.1 a	11.0 b	11.0 b	14.6 a	10.5 b	12.2 b
Fruit wt. per pruning wt. (kg/kg)	3.1 b	6.3 a	7.2 a	3.2 a	5.7 a	5.9 a	5.4 b	8.9 a	7.9 a
Canopy descriptors									
Total shoots per vine	52.9 a	54.4 a	59.4 a	75.6 b	79.3 b	90.9 a	68.1 b	72.2 ab	76.2 a
Weak shoots per vine	8.9 b	9.5 ab	11.6 a	11.1 b	12.8 b	16.9 a	.	.	.
Leaf area per vine (1000 cm^2)	115.6 a	118.8 a	129.9 a	140.8 b	145.4 b	161.6 a	148.7 b	157.7 ab	166.5 a
Cane pruning wt. (kg/vine)	2.1 a	2.2 a	2.5 a	2.4 a	2.4 a	2.5 a	1.9 a	1.8 a	2.0 a
Leaf layers	0.5 a	0.6 a	0.6 a	1.0 a	1.1 a	1.1 a	1.8a	1.6a	1.7a
Canopy gaps (%)	42.1 a	28.2 b	31.9 ab	17.6 a	13.9 b	10.7 c	4.0a	4.4a	4.8a
Exposed fruit clusters (%)	99.0 a	95.5 a	86.7 b	84.2 a	73.7 b	75.6 b	62.9a	61.1a	55.7a
PAR in fruit zone (% of ambient)	14.2 a	12.5 a	11.9 a	6.0 a	5.3 a	6.2 a	2.4a	2.1a	2.1a
Actual PAR level (uMol/m^2/sec)	231.4 a	199.8 a	179.4 a	80.5 a	59.8 b	75.0 ab	42.4a	37.1a	38.4a

[y] Mean separation by Duncan's multiple range technique. Means for a given response, within years, followed by the same letter are not different at $P < 0.05$.

[z] Based on extrapolation to 519 vines per acre.

Table 2. Components of yield and canopy characteristics of Chardonnay grapevines as affected by three crop levels during the 1998 and 1999 growing seasons.

	1998 season			1999 season[§]		
	Low	**Moderate**	**High**	**Low**	**Mod.**	**High**
Components of yield						
Clusters/shoot before thinning	1.34 a	1.24 b	1.15 c	0.82 a	0.67 b	0.69 b
Clusters per vine	44.0 c	71.8 b	93.6 a	47.8 b	.	76.1 a
Cluster wt. (g)	186.8 a	159.5 b	123.5 c	264.6 a	.	200.7 b
Berry wt. (g)	1.53	1.57	1.60	1.91 a	.	1.83 a
Berries per cluster	123.1	111.4	77.0	138.0 a	.	109.4 b
Fruit wt. per vine (kg)	8.2 b	11.4 a	11.7 a	12.6 b	.	15.1 a
Tons per acre equivalent[z]	***4.7***	***6.5***	***6.7***	***7.2***	**.**	***8.6***
Leaf area per fruit wt. (cm^2/g)	16.0	12.2	11.6	.	.	.
Fruit wt. per pruning wt. (kg/kg)	3.2	4.4	4.3	6.0	.	8.4
Canopy descriptors						
Total shoots per vine	69.8 ab	71.9 a	67.4 b	.	.	.
Weak shoots per vine	13.6 a	12.2 ab	9.3 b	.	.	.
Leaf area per vine (1000 cm^2)	130.8 a	139.0 a	135.5 a	.	.	.
Cane pruning wt. (kg/vine)	2.6 a	2.6 a	2.7 a	2.1 a	.	1.8 a
Leaf layers	1.6 a	1.6 a	1.7 a	2.0 a	2.1 a	1.8 a
Canopy gaps (%)	7.1 a	6.8 a	6.4 a	1.2 b	3.2 ab	4.4 a
Exposed fruit clusters (%)	76.9 a	74.3 a	67.5 a	61.5 a	50.0 a	56.1 a
Wood maturity (October)						
Total nodes/shoot	17.3 a	17.2 a	16.9 a	.	.	.
Mature nodes/shoot	13.1 a	12.7 a	12.6 a	.	.	.
Percent mature nodes/shoot	74.1 a	71.3 a	72.6 a	.	.	.

[z] Based on extrapolation to 519 vines per acre.

[§] The moderate crop level was not evaluated in the 1999 season.

Table 3. Effect of low (L), moderate (M), and high (H) crop levels on Chardonnay grape chemistry at harvest for three seasons.

Harvest Date	**9/21/95**	**9/21/95**	**9/21/95**	**9/26/96**	**9/26/96**	**10/10/96**	**10/8/97**	**10/8/97**
Treatment	**L**	**M**	**H**	**L**	**M**	**H**	**L**	**M**
orix	23.2a	22.1b	20.8c	21.0a	21.0a	21.a	21.3a	21.6a
pH	3.75a	3.73a	3.76a	3.61a	3.59a	3.34a	3.67a	3.62b
TA (g/L)	5.5a	5.4b	5.7a	7.4a	7.6a	7.2a	6.6a	5.8b
Sugar/berry	35.9a	35.6a	32.4b	37.5a	36.6ab	36.6a	40.2a	39.1a
TPHE (AU)[a]	7.0a	5.7b	4.9c	6.1ab	6.6a	5.6b	5.4a	4.5b
TCOH (AU)[b]	4.4a	3.4b	3.6b	4.2ab	4.4a	3.4b	4.1a	3.5b
CAE (mg/L)[c]	48.8a	37.6b	39.8b	46.6ab	48.8a	37.2b	45.7a	39.3b
TFLAV (AU)[d]	4.1a	3.5b	2.5c	3.3ab	3.7a	3.4b	2.6a	2.2b
TGPG (x10)[e]	2.1a	1.5b	1.6b	1.8a	1.6b	1.6b	1.4a	1.5a
PFGPG (x10)[fg]				0.9b	1.1a	1.0b	1.1a	1.0a
Ammonia N[h]							53.8a	41.5b
Amino[i]							15.3a	13.9b

[a,b,d]Total phenols, total hydroxycinnamates, and total flavonoids (expressed as absorbance units).

[c,e,f]Caffeic acid equivalents, total glycosyl glucose per gram, and phenol-free glycosyl glucose per gram.

[g]Data not acquired for PFGPG for 9/21/95.

[h,i]Data not acquired for these characteristics for 9/21/95, 9/26/96, or 10/10/96.

Treatment means with the same letter are not significantly different at $P<0.05$.

Table 4. Effect of three duo-trio difference test of crop loads [low (L), moderate (M), and high (H)] on Chardonnay wine aroma and flavor in 1995.

L vs. M	25/7	*	20/12	NS
M vs. H	22/8	*	21/8	*
L vs. H	36/24	*	39/21	*

Data are correct/incorrect responses with significance at

Table 5. Effect of three duo-trio difference test of crop loads [low (L), moderate (M), and high (H)] on Chardonnay wine aroma and flavor in 1996.

L vs. M	14/28	NS	19/28	*
M vs. H	15/28	NS	19/28	*
L vs. H	17/28	NS	15/28	NS

Data are correct/incorrect responses with significance at $P<0.05$.

Table 6. Chardonnay crop load data of 2000 growing season.

	High		**Moderate**		**Low**	
	Cane	Spur	Cane	Spur	Cane	Spur
Clusters/vine	119a	104ab	76c	87bc	24d	25d
Cluster wt. (g)	181b	187b	172b	186b	315a	270a
Crop/vine (kg)	21.6a	19.4ab	13.2c	16.2bc	7.7d	6.6d
Tons/acre	**12.4a**	**11.1ab**	**7.5c**	**9.2bc**	**4.4d**	**3.8d**
Clusters/shoot	1.5a	1.2b	1.2b	1.3b	1.5a	1.2b

Table 7. Chardonnay crop load data: 2000

	Spur-pruned		
	High	**Moderate**	**Low**
Tons/acre	11.1	9.2	3.8
Brix	20.9 b	22.4 a	22.2 a
PH	3.40 a	3.32 b	3.27 c
Ripe	10.6 b	11.8 a	12.1 a
Ripe	71.5 b	69.6 b	76.4 a

EXTRACTION OF COLOR AND FLAVOR IN RED WINE

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Color and flavors are the distinguishing attributes of a red wine. The main constituents responsible for these parameters are phenolic substances (including pigments) and other varietal aroma compounds. Extraction and subsequent management of these compounds play an important role in determining the style and quality of red wines. For example, a light extraction will yield a fruity red wine with lighter body and low tannin suited for early consumption. On the other hand, a heavily extracted wine would be dark, tannic, full-bodied with complex aroma and would require long aging.

In red wine vinification the phenolic compounds, mostly flavonoids, are extracted from skins, seeds, and occasionally stems. The nonflavonoid phenolics found in pulp are common to both white and red wine. Only a portion of total grape phenols is extracted in the wine. In commercially produced red wines the total phenol content is in the range of 1100 to1800 mg GAE/L (Singleton, 1980).

FLAVONOIDS

Both, the pigments and the tannins belong to the flavonoid group of the phenolic compounds. The molecular structure of the flavonoids is based on the C-15 (C6-C3-C6) carbon skeleton which consists of two 6 carbon aromatic rings A and B joined by a 3 carbon oxygen containing pyran ring. The 3-ring flavonoid structure with numbered carbon is shown in Figure 1. A ring

In all the flavonoids of grapes and wine (with few exceptions) the A ring is substituted with two hydroxyl (OH) groups on C-5 and C-7 positions.

C ring

Structural differences in C ring generate various classes of flavonoid compounds. Of the many flavonoid classes the important ones include:

Flavanols
Anthocyanidins
Flavonols

Figures 2a 2b and 2c show the examples of a flavanol (catechin) anthocyanidin (cyanidin) and a flavonol quercetin. Note that variation in the oxidation state of C ring has produced the three classes of flavonoids mentioned above (Allen, 1997).

B ring

The substitution on ring B gives rise to the members of a flavonoid class. Generally the substitution pattern involves hydroxylation at position C3' C4' and C5' and methylation of hydroxyl groups at positions C3' and/or C5'. Table 6 lists the various members of the 3-flavonoid classes resulting from the different substitution pattern on C and B rings.

ANTHOCYANINS

Anthocyanins are pigments responsible for the red and purple color of grapes and wines. They consist of an anthocyanidin linked to glucose at C3 or C3 and C5 positions. The presence of sugar (glucose) in the anthocyanin structure makes pigment more soluble and stable. In many cases the sugar is further bound to an acid. Commonly found acids include acetic, p-coumaric and caffeic acids. The pigment is then called acylated. Anthocyanins containing one glucose molecule (C3 position) are called monoglucosides and those containing two glucose units are called diglucosides. Vinifera grape varieties contain only monoglucosides; whereas, most of the hybrids (derived from *V. riparia* and *V. rupestris*) contain diglucoside anthocyanins. Labrusca grape varieties also contain diglucoside as well as monoglucoside pigment. The significance of this point is that the presence of diglucoside in wine indicates nonvinifera origin, but the absence is not proof of a vinifera wine.

The property of the color and stability to oxidation is related to the substitution pattern in B ring. For example, increasing the number of OH groups on the B ring increases blueness; whereas, an increase in methylation of OH groups shifts color towards redness (Jackson, 1994). Increasing OH groups in B ring also increases the sensitivity of the pigment to oxidation. As an example, derivatives of cyanidin (with two OH groups on adjacent carbon) would be more susceptible to oxidation then malvidin.

A large number of pigments are found in grapes and wines. The commonly found anthocyanidins, their color and the substitution pattern on B ring is given in Table 1.

Various combinations of anthocyanidins, sugars and acylation pattern give rise to a large number of anthocyanins. Thus the characteristic color of the wine is due to the presence of a mixture of many types of anthocyanin pigments. Of the numerous pigments found in wine, malvidin is the major one in dark vinifera fruit with higher proportions of cyanidin in red and delphinidin in the blue grapes of labrusca varieties (Singleton, 1980). Generally the anthocyanin content of dark grapes ranges between 30 to 750 mg/per 100 gm of ripe berries (Fuleki, 1990). The total anthocyanin content is influenced by many factors such as variety, maturity, seasonal condition and viticultural practices.

Forms of anthocyanins

In a mildly acidic aqueous solution such as wine, the free (monomeric) anthocyanins exist in various forms which remain in pH dependent complex equilibria. These different forms for malvidin glucoside are shown in Table 2..

The red pigment form is called the flavylium cation form. Obviously being a cation it is positively charged. The red cationic form remains in equilibrium with colorless carbinol hydrated pseudobase (pK 2.6) which is also in equilibrium with another form called chalcone. In a separate interaction the red form equilibriates with the quinoidal base form which gives a violet color (pk 4.25). It should be clear that the color will depend on the proportions of the various pigment forms present in the wine. Since the equilibrium reactions are pH dependent, they will have a strong influence on the proportions of different pigment forms, and therefore, on the color. For example, in the case of malvidin glucoside at pH 2.6, the red and the colorless form will be present in equal amounts. This means that at a typical wine pH in the range of 3 to 4, the proportion of red pigment form would be less than 50% and it will further decrease with a rise in pH. At pH 3.25 the amount of malvidin glucoside in wine is calculated to be only 20% (Margalit, 1997). The proportions of colored and colorless forms would be different for different types of anthocyanins. Generally, at wine pH, colorless free anthocyanins predominate. As the pH is lowered the proportion of red pigment form increases and the red color becomes more intense.

Reaction with sulphur dioxide

The reaction between the negatively charged bisulphite ion and the flavylium cation generates a colorless bisulphite addition compound (Fig 5).

The reaction is reversible and therefore, loss of bisulphite will restore the color. The contribution of the free anthocyanin pigments to wine color will depend on the pH, the free SO_2 and the age of the wine.

In a young red wine free (monomeric) anthocyanins play an important part in determining wine's color. As the wine matures the monomeric pigments are progressively incorporated into polymeric forms which are less sensitive to pH and free SO_2 content of the wine

Copigments and self association

The intensity of the color is enhanced when certain compounds are present in association with the pigments. These color enhancing compounds are called copigments. They include colorless flavonoids, polyphenols, amino acids, organic acids and other constituents.

In some cases an increase in color intensity was found to be much greater than can be accounted for due to higher anthocyanin content alone. It is believed that the mechanism of color enhancement in both self association and copigmentation cases is due to the formation of

vertically stacked molecular aggregates, held by molecular interactive forces (Somers and Verette, 1988).

FLAVAN-3-OL (CATECHINS)

Flavan-3-ols are an important subclass of monomeric flavonoid found in grapes and wine. The main members of the class are (+) catechin, (-) epicatchin, and the minor ones include gallocatechins and epicatechin gallates. Their concentration is high in seeds but a small amount is also found in the skins. The amount of catechin and epicatechin widely vary among grape varieties. In most of the red wines the catechin content was noted to be in range of 50 to 200 mg/L and the epicatechin level was found to be about 40 to 100 mg/L (Waterhouse and Teissedre, 1997). The flavan-3-ols are also found in dimeric and polymeric forms, which are considered condensed tannins.

TANNINS

Wine tannins are polymers of flavanol. They are astringent compounds and have the ability to complex with proteins. Their molecular weight ranges between 500 to 5000 (Singleton, 1988). They include dimers, oligomers and polymers. The length of polymer chain depends on the degree of polymerization. Polymers containing about 2 to 8 flavanol units are also called procyanidins. They constitute a major fraction of polymeric phenols and their reaction with anthocyanins generates polymeric pigments (Boulton et al, 1996).

Tannin structure

Tannins are very complex molecules. The complexity can be attributed to the structural differences between the flavanol units, the number of units linked in the polymer chain and variation in the site of linkage between the flavanol molecules. Usually the flavan units include (+) catechin, (-) epicatechin and (-) epicatecgin-3-o-gallate. The units are typically linked at C4 and C8 positions (Fig. 6), but C4-C6 linkage is also found. The number of flavanols in the polymer chain will vary according to the degree of polymerization. A very high degree of polymerization can make the polymer too large to remain in solution.

Tannin polymerization reaction

Procyadin is considered to be a very reactive subunit which constitutes tannin polymer through condensation and polymerization. These reactions can occur with or without the presence of oxygen. Ribereau-Gayon and Glories (1986) explained the reactions as follows:

With oxidation, procyadin condenses to form tannins (T) which are pale yellow, and very astringent.

Without oxidation, procyadin can polymerize to yield condensed tannins (CT) that are

yellow-red and less astringent than tannins.

A greater degree of polymerization produces highly condensed tannins (TtC) of a yellow-brown color.

Polymerization can also involve participation by other compounds such as polysaccharides (tannin-polysaccharide complex, TP) and peptides which makes tannins less astringent and more supple.

Other important polymerization of tannins with anthocyanins is already mentioned.

CHANGES IN PIGMENTS AND TANNINS DURING GRAPE MATURATION

Pigments and tannins are derived from grapes. Knowledge of changes in these constituents particularly during maturation is necessary in determining the quality of harvest. The composition of grapes during maturation is influenced by several factors such as cultivar, climatic conditions, and viticultural practices. At veraison the anthocyanin pigments appear and continue to accumulate as the berry matures and ripens. The pigments are located only in the skins and are responsible for the color of the berry. The skin tannin level is fairly high at veraison and continues to rise towards berry ripening. In seeds, the tannin content is high at veraison and tends to decrease during maturation, but still remains higher than in the skins at harvest (Ribereau-Gayon and Glories, 1986).

COLOR AND FLAVOR EXTRACTION DURING RED WINE VILIFICATION

In red wine vinification, the color and flavor constituents are extracted from skins, seeds, and occasionally, stems. As stated earlier, only a portion of the phenolics present in the solid tissue is extracted into wine. The degree of extraction and subsequent management of the phenolics depends on the intended style of wine. Now let us consider the impact of important winemaking steps on the extraction of phenolic compounds with special emphasis on the constituents responsible for color and flavor of the wine.

Destemming and crushing

A winemaker has several choices regarding crushing and destemming the grapes. They are:

No crushing and destemming

In making red wine using the carbonic maceration procedure, no crushing and stemming is followed. The whole clusters are deposited into the fermenter and flushed with carbon dioxide. The berries own enzyme system causes fermentation within the berry. A small amount of ethanol (about 1.5 to 2%) is produced during carbonic maceration. The fermentation occurs for about 8 to 10 days at 32 to 35 °C. Following partial fermentation the clusters are pressed, inoculated with

yeast, and fermented without skins and seeds. Both the color and phenolics are lightly extracted. This approach yields wine with a distinctly fruity aroma, lighter color, and low tannins.

Partial destemming and crushing

In this procedure a certain amount (about 20%) of whole berries are retained in the fermenter. Usually all stems are removed but some winemakers prefer partial stem return. The fermentation is relatively slow and prolonged. Resulting wines have enhanced fruit character and low phenolic content. Retaining some stems in the fermenter can boost tannin level but sometimes add herbaceous notes and harsher tannins to the wine. Stems can also adsorb pigments and thus reduce the wine's color.

Complete destemming and crushing

As the name implies all the stems are removed and the berries are gently crushed. Gentle handling is crucial. Vigorous crushing and aggressive handling which results in chopping stems, grinding stems and breaking seeds should be avoided in order to minimize the extraction of harsh, bitter, and astringent phenolic compounds.

Cold soak

In this winemaking technique the must is held at a cooler (15 °C) temperature for a few days before beginning the fermentation. During the holding period the must may be pumped over once or twice a day to promote mixing and extraction. It is believed that maceration in the absence of ethanol improves the aromatic intensity of the wine. It can be useful with lighter bodied varieties such as Pinot Noir (Wollan, 1998).

Extraction pattern of skin and seed component

Anthocyanins are extracted rather rapidly, their level reaches maximum within the first few days (2 to 3 days) of fermentation and then slightly decreases during the remainder of the fermentation. Along with color the aroma compounds from skin are easily extracted. This is why, with well-ripened fruit, a short skin contact can produce a fruity wine with good color but low tannin.

Tannins and other phenolics are extracted more slowly than pigment at first, but their levels continue to rise until the must is pressed. Tannins contribute to the taste, body, mouthfeel (suppleness) and color stability and aging potential of a wine.

Many other compounds such as polysaccharides, pentoses, minerals and odorous substances are also extracted. It is important to remember that besides simple extraction many reaction occur. These reactions such as pigment polymerization and tannin condensation and polymerization have a significant influence on the color and flavor of the wine.

Cap management techniques

Vinification of red must involves fermenting juice in contact with skins and seeds. With the onset of fermentation as carbon dioxide is produced, the skins and the seeds rise to the top forming a thick layer of must called the cap. Cap formation largely separates skins and seeds from the fermenting liquid below. The cap also traps heat generated during fermentation. In order to release heat and promote extraction of skin and seed constituents, the cap is broken and thoroughly mixed with the fermenting juice.

Cap management is one of the most effective winemaking techniques used by winemakers to promote color and flavor extraction during fermentation. The winemaker has several options for manipulating the cap. The major ones include:

Punching down
Pump-over
Rototanks
Submerged cap

Punching down

When fermenting smaller lots (1 ton in a bin), punching down the cap is a common and effective way to manipulate the cap. A hand held plunger can be used to break the cap and mix the must. The shape of the fermenter will have an effect on the thickness of the cap. A shallow fermenter (wider and less tall) will produce a relatively thinner cap than a tall fermenter with a small diameter. A thinner cap is easier to manipulate and gives better extraction.

Many winemakers use stainless-steel fermenters with a relatively low height-to-diameter ratio (1 to 1.3) which produces a cap that can be conveniently managed (Zocklein et al, 1995). In larger volumes of fermenting must, the cap can be too thick (deep) and difficult to handle manually. In these situations various mechanically operated punching devices can be employed.

Pump-over

In the pump-over technique the wine is drawn from the racking valve below the cap level and pumped over the top of the cap. Generally the wine is splashed over the cap by using a sprinkling device or a spray jet. The operation is done two or three times a day and one to two volume of wine is pumped.

A variation of the pump-over method is called "drain and return" or delestage. According to this procedure the wine from the fermenter is drained into a sump and then pumped into another tank. Aeration is encouraged during pumping. When the cap falls to the bottom it is allowed to rest for several hours and drain freely. The wine is then returned to the fermenter by gently pumping over the cap resting at the bottom. With each draining, a certain amount of seeds are

removed. It is claimed that this minimizes the extraction of harsh, immature seed tannins into the wine. The frequency of this operation will vary, it can be done daily or every other day. The winemaker should evaluate the technique before adopting it. Red wines produced by the delestage method were found to show reduced astringency and increased the level of polymeric pigments.

In recent years several designs of automatic pumping-over systems have been introduced. They seem to do an efficient job of cap management and extraction of skin and seed constituents.

Rototanks

Rotary fermenters are becoming increasingly popular with red wine producers. Due to the horizontal configuration the cap is shallow and the mixing of the cap is very thorough. The extraction of color and tannins is faster and efficient. They are expensive but can be cost effective when handling larger volumes.

Submerged cap

In this approach a screen is installed in the fermenter. The screen holds the cap and keeps it submerged in the fermenting juice. With the cap submerged, a good extraction of color and flavor would be expected, but poor circulation of liquid within the cap has produced less than satisfactory results.

Skin contact time

The length of skin contact has a profound influence on the extraction of skin and seed constituents. As mentioned above the anthocyanin extraction peaks early in fermentation, while tannins continue to be extracted until the must is pressed. This means the timing of pressing can be used to influence the relative proportion of color and tannins in wine. The criteria for choosing the length of skin contact time would then be:

The relative proportion of fruity aroma, color, and tannin level the winemaker would prefer in the resulting wine. This is the wine style decision.

The quality of the vintage means the fruit must have the desired color, fruit flavor and tannin, (both in quality and quantity) to make the intended style of wine.

Typically the must is pressed at about 5 to 0 °B. With high quality, ripe fruit, this is sufficient contact time to make good red wine. A shorter pomace contact would yield a wine with good color but lower tannins. Conversely, late pressing would produce a tannic wine with fuller body but somewhat diminished color.

Traditionally in Bordeaux, and now in many red wine producing areas, winemakers practice postfermentation extended maceration. In this approach the must is held in a sealed tank or a

closed tank with a CO_2 blanket. Depending on the variety and the quality of the fruit, the maceration is conducted for 20 to 45 days. During this prolonged maceration, extraction of constituents mostly from seeds and some from skins continues. Pigments and tannin polymerization proceeds and new compounds containing polysaccharides, peptides and yeast cell derived materials are formed. Wine produced with this method is high in tannins (which soften with age), has fuller body, and rich, complex flavors.

Temperature

Red must is usually fermented at a temperature ranging from 25 to 30 °C. For producing fruitier aromatic wines, a lower fermentation temperature (20 to 25 °C) is preferred. For obtaining darker, richer, and tannic wines the must is fermented at a higher temperature (30 °C). In general fermentation at higher temperature promotes extraction of both the anthocyanins and tannins. To facilitate the extraction using heat, Ribereau-Gayon and Glories (1986) developed a "high temperature final maceration technique." According to this technique, at the completion of fermentation the must is heated to 40 °C for 24 to 48 hours. The resulting wine is generally rich in tannins and has a smoother finish. The response to heat treatment will depend on grape variety and fruit composition.

Sensory effects

Phenolics extracted from skins and seeds are responsible for the color and flavor of red wine. In a new wine the free anthocyanins are primarily responsible for the red color. But the formation of polymeric pigments begins early in fermentation and by the end of primary fermentation polymeric pigments would generally account for at least 25% of the color density (Somers, 1980). In a young wine both free and polymeric pigment contribute to the wine's color. With aging, polymeric pigments increasingly contribute to red wine's color, and the color becomes more stable.

Flavonoid phenolic compounds are bitter and astringent. In wine they include monomers (catechins), dimers, and polymers. Monomers are more bitter than astringent, As the molecular size increases astringency increases in relation to bitterness. As the wine ages phenols are polymerized and bitterness diminishes. Other aging reactions occur. Some of the extracted constituents degrade while many new compounds are formed.

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Table 1. Structural Variation in Ring C and Substitution on Ring B	
Variation in C ring Structure	B ring Substitution of Members
Falvanol (Flavan-3-ol)	Catechin, Epicatechin, C3' C4' -OH
	Gallo-Catechins, C3' C4' and C5' -OH
Anthocyanidin	Cyanidin, C3' C4' -OH
	Delphinidin, C3' C4' C5' -OH
	Peonidin, C3' -OCH3, C4' -OH
	Petunidin, C3' -OCH3, C4' C5' -OH
	Malvidin, C4' -OH, C3' C5' -OCH3
Flavonol	Quercetin, C3' C4' -OH
	Myricetin, C3' C4' C5' -OH
	Kaempherol, C4 OH

Table 2. Major Anthocyanidins of Grapes				
		Substitution Pattern in B ring		
Anthocyanidin	Color	C3'	C4'	C5'
Malvidim	Bluish-red	OCH3	OH	OCH3
Cyanidin	Orange-red	OH	OH	H
Peonidin	Orange-red	OCH3	OH	H
Delphinidin	Bluish-red	OH	OH	OH
Petunidin	Bluish-red	OCH3	OH	OH

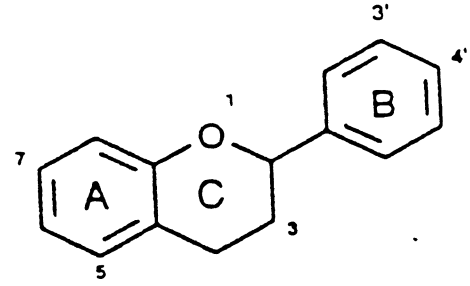

Figure 1. Flavonoid ring structure.

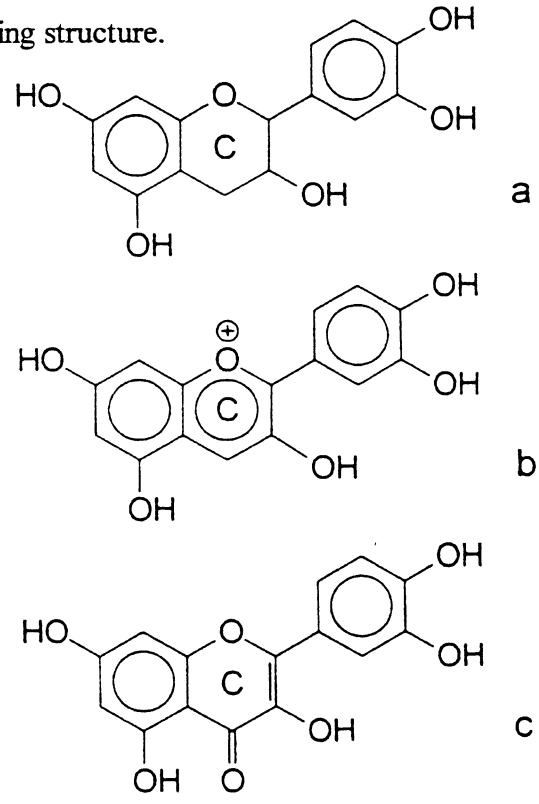

Figure 2. Structural variation in ring C.
a. Flavanol (chatechin or epicatechin)
b. Anthocyanidin (Cyanidin)
c. Flavonol (quercetin) (Allen, 1998)

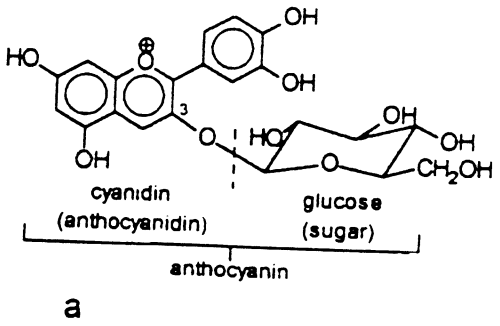

Figure 3a. Anthocyanin

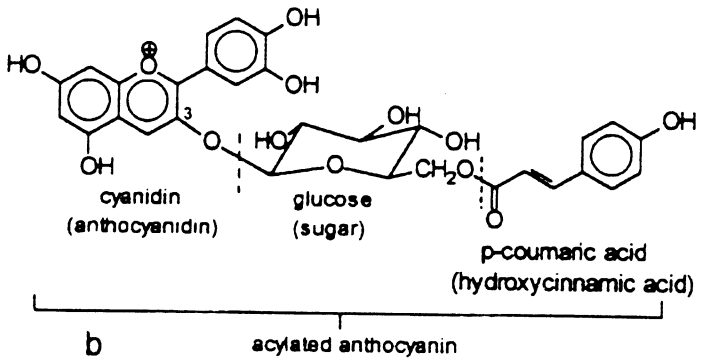

Figure 3b. Acylated anthocyanin (Allen, 1998)

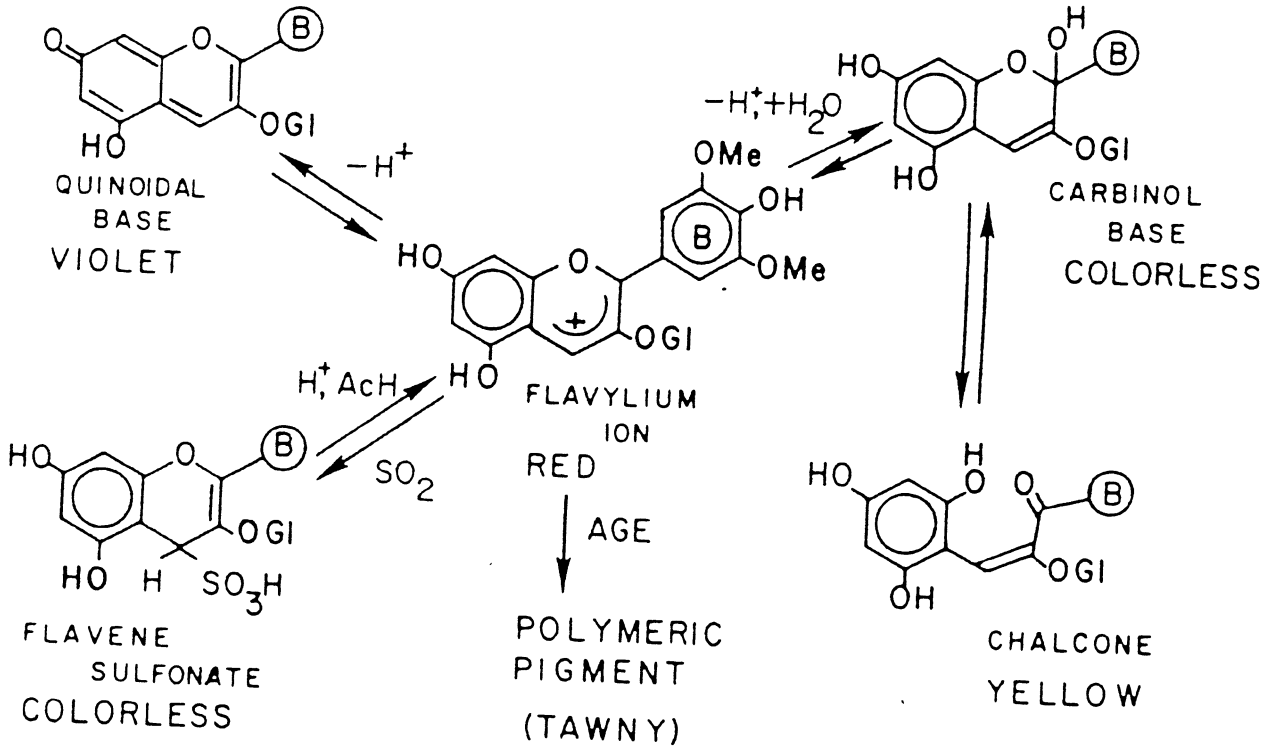

Figure 4. Anthocyanin equilibria and reactions (Singleton, 1988)

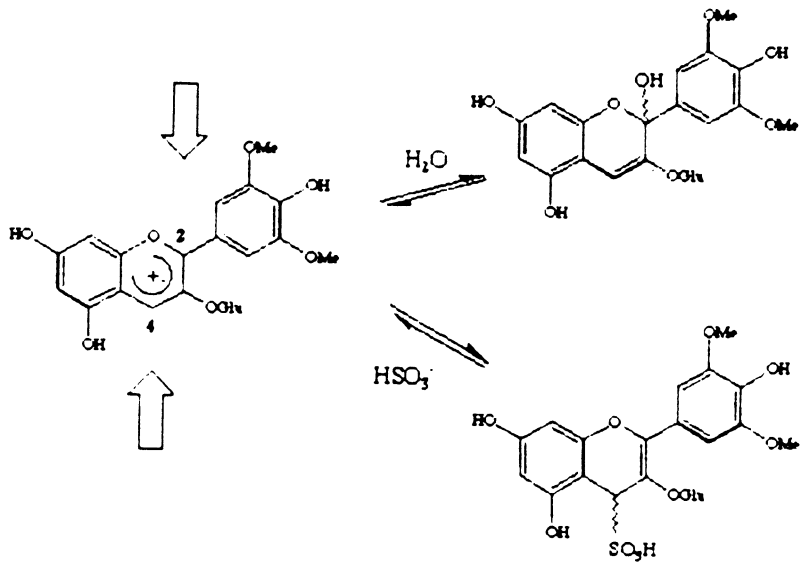

Figure 5. Reaction of flavylium cation with HSO^-_3 ion (Allan, 1988)

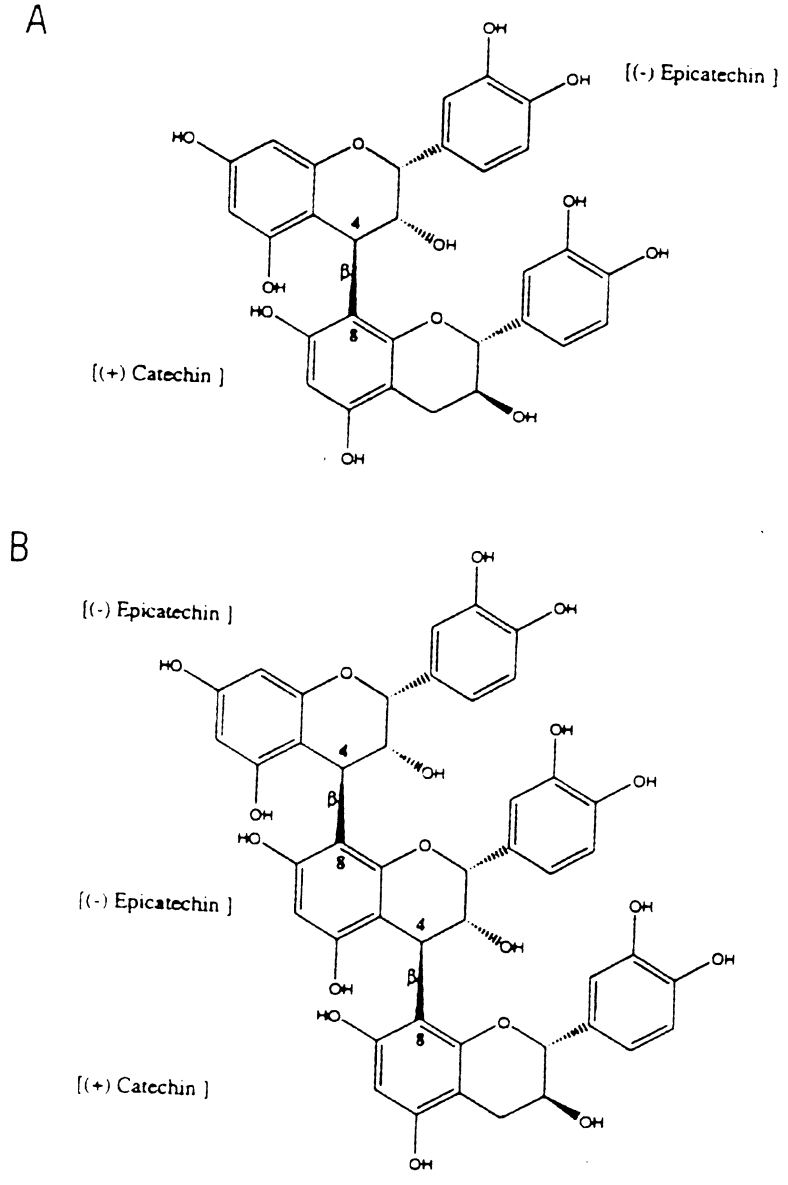

Figure 6. Examples of common dimer and trimer procyanidins found in grape berries.

A. Dimer B1: epicatechin - (4>8) - catechin

B. Trimer: epicatechin -(4 â > 8)-epicatechin- (4 â > 8) - catechin (Gawel, 1998)

INFLUENCE OF JUICE CLARIFICATION ON WHITE WINE QUALITY

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For making white table wines, juice clarification prior to fermentation has become a widely accepted practice. Most wineries recognize the importance of juice clarification in making high quality white table wines. Singleton et al. (5) described the wines from clarified juice as being fresh, clean, delicate, and fruity. Their research also found that wines made from turbid juice were described as being harsh, which was related to the high bitterness and astringent ratings. Similar results were found in Ohio where wines from clarified juice tended to have a clean and fruity aroma with varietal character (1). These wines were preferred by taste panelists to those from unclarified juices. Other research has indicated that juice clarification is beneficial in removing pesticide residues (7) and undesirable microorganisms (6) and prevention of H_2S formation (5). In addition, Crowell and Guymon (1) and Groat and Ought (2) reported that an increase in juice solids caused a higher formation of higher alcohols. These findings were in agreement with the Ohio studies by Liu et al. (4). Wagener and Wagener (8) found that higher values of higher alcohols in white wines were detrimental to wine quality. Also, the formation of higher alcohols in wines was found to be related to the particle size of the juices. Klingshirn et al. (3) reported that the greatest amounts of higher alcohols were obtained from wines fermented in the presence of the largest particles.

In order to obtain clarified juices prior to alcoholic fermentation, several methods may be used to remove the insoluble solids. These methods include settling, filtration or centrifugation. In general, settling juice is the most common method of clarification. This method is preferred, especially among the small wineries because the high cost of clarifying by filtration and centrifugation. For settling, it is recommended that the juice be cooled to approximately 55°F for at least 12 hours with a satisfactory level of sulfur dioxide, about 50 mg/L. Although these conditions are often used by the winemaker, adequate clarification may not be achieved for some juices. The amount of insoluble solids is influenced by several factors including grape maturity, season, fruit condition and variety. Research in Ohio found that sound fruit without rot yielded less solids. Also, some varieties are recognized as having high solids, such as White Riesling, and over-ripe fruit tend to produce more solids. For grape temperatures at crushing, cool fruit produce less sediment in the juice.

In order to ensure adequate clarification for high solids juice in less time, some winemakers use pectic enzymes. The use of these fining agents also offers the winemakers the advantage of using less tank space during the peak of the crushing season. An Ohio study was conducted to investigate the effect of treating juice with a pectic enzyme and its effect on white wine quality (4). Results indicated that wines from clarified juice were generally preferred in both aroma and taste to those from unsettled juice. Furthermore, these experiments showed that enzyme-treated wines produced a better quality wine than wines from unsettled and natural settled juices. The

enzyme-treated wines tended to have a clean and fruity aroma with good varietal character. Several commercial pectic enzymes are available for juice clarification.

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THE ART OF FINING WINES
A REVIEW OF FINING AGENTS & TECHNIQUES

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The art of 'fine' tuning the aromas and flavors of a wine by the addition of various compounds is not a new tradition. The Egyptians and Greeks added herbs and spices to mask unpleasant flavors thousands of years ago. The use of proteinaceous substances such as egg white has been common practice for hundreds of years. Modern winemakers have a wide range of compounds, which can be passed through wine to change somewhat specific aspects of its nature. This paper will deal with the theory of wine fining and the various materials available to do the job.

Since all fining agents are capable of removing more than the offending compound, winemakers should follow the following golden rules before considering adding anything:

- ✓ Always do lab evaluations before bottling wine
  - Acid profile: pH, Total Titratable Acidity, Volatile Acidity
  - Residual Sugar
  - Sulfur Dioxide – SO_2
  - Alcohol
  - Heat and Cold Stability
  - Organoleptic problems
- ✓ Always do fining trials before treating wine
- ✓ If you don't need fining to correct a specific problem, don't do it!!

Wine Analyses

Heat Stability

Supplies:
1) 0.45 micron filter setup
   Filter Funnel - Fisher Cat. # K953755-0000 @ $70
   Membrane Filters, MicronSep 1 + PACs, 100 filters
   Fisher Cat. # EO4WGO47S2 @ $34
   Filter Flask, Polyproplyene, 1000 mL
   Fisher Cat. # 10-182-50B @$13
   Vacuum aspirator, Nalgene
   Fisher Cat. #09-960-2 @ $6
   Vacuum tubing, Tygon (clear), 12 ft. pack
   Fisher Cat. #14-169-2B @$36
2) Small, clear glass, screw capped bottles 50 - 100 mL volume.
3) Oven or water bath to maintain temperature of 80C (206F)

Procedure:

1) Filter wine to fill two screw capped bottles, label
   a) Room Temperature
   b) Heated
2) Place bottle (b) in incubator at 120F, 24 hours, cool slowly to room temperature, examine
3) Examine heated and unheated samples at 1 hr, 6 hrs & 24 hrs under high
   a) intensity light
4) Clouding, precipitate in heated sample indicates protein instability

Cold Stability:

1) Clarify (not filtered) sufficient wine to fill 2 screw-capped bottles.
2) Place 1 in freezer for 1-2 days, refrigerate other.
3) Allow thawing at room temp., observing for crystals, which do not dissolve on shaking.
4) Frozen sample - few crystals, wine probably acceptable
5) Refrigerator sample - few crystals, consider more cold stabilizing, especially in white wines.

Effect of Fining Agents

Fining agents can correct or affect the following wine characteristics:

- ✓ Color - intensity, browning
- ✓ Aroma - excessive varietal character, Hydrogen Sulfide - H_2S, oxidation
- ✓ Flavor - bitterness, astringency
- ✓ Metal problems - copper, iron
- ✓ Hazes
- ✓ Cold instability
- ✓ Heat instability

Fining trials must be done with the same materials used to treat bulk wine:

Same batch of fining agent
Same dose concentration
Same temperature

Note & record how each fining trial affects:
clarity, lees formation & compaction, heat stability, aroma character & intensity, color, body, astringency, bitterness, finish

Factors Which Improve Fining Action

- ✓ Low carbon dioxide

- ✓ Low pH
- ✓ Warm temperature
- ✓ Hi tannin level
- ✓ Dry wines
- ✓ Clear wines
- ✓ Young wines

Classes of Fining Agents

Earths: bentonite, kaolin (- charge)
Proteins:gelatin,isinglass,casein,albumen (+)
Polysaccharides: Sparkolloid, Klear-mor (-)
Activated Carbons
Synthetic polymers: PVPP, nylon
Silicon dioxide: Nalco 1072, Keiselsol (-)
Others: metal chelators, enzymes, etc.

Order of Addition of Fining Agents

Copper & iron treatment
Acid adjustments (if necessary)
Tannin, color, aroma reductions
Protein reduction
Clarification

WINE FINING AGENTS

Activated Carbon

Characteristics:

Fine black powder, microporous surface, adsorptive action, especially for small phenolic compounds - removes color, odor.

Use:

Addition of ascorbic acid (0.05-0.1%) to wine before carbon addition may reduce oxidative damage.
Instant reaction with carbon, remove as soon as possible
bentonite or PVPP fining, racking, filtration (plate & frame).
In line addition of carbon with Diatomaceous Earth body feed during filtration is ideal.

Preparation:

None

Problems:

Fine powder gets everywhere
Excess treatment, carbon flavor, stripping color and aroma.
Difficult to remove from wine.

Albumen

Characteristics:

Fresh or frozen egg whites, fresh are most effective; frozen, easier.

Preparation:

beat desired volume egg white to a froth
mix with 10 volumes wine, then stir into main volume wine.
BATF: 28.35 g KCl + 907 gm egg white, 1 gal (3.8 L) water, beat well,
Max. allowable (BATF) = 1.5 gal albumen solution/1000 gal wine.

Use:

Add prepared whites or solution slowly
Constant vigorous agitation at point of contact
Albumens coagulate immediately.
Allow to settle and rack off ASAP.
Delicate treatment - soften tannin character in red wines.
Not used in whites, lack of tannins = protein instability.

Problems:

Whites must be very fresh, < 2 hours after preparation
No yolk!
No BATF limit (GRAS) except solution described above

Bentonite

Characteristics:

Montmorillonite clay, aluminum silicate,
expanding crystal lattice structure
1 gram bentonite provides 50 sq. feet of surface area
Positive charges surfaces capable of adsorbing negative charged proteins. Best protein removal treatment
Big pH effect, pH 3.0 wine needs 75% less than pH 3.6 wine.
Hi alcohol, low tannin, low pH, warm, clear wines need less bentonite

Preparation:

KWK agglomerated bentonite easiest to prepare:
Weigh bentonite to prepare 5% solution

Heat water to 50-60 C (130F)add bentonite very slowly while stirring rapidly and continuously.
Allow 1 day of occasional stirring to fully hydrate to smooth slurry.
Will keep in refrigerator for several months if well sealed.

Use:
Add determined amount while gently stirring wine, allow to settle
Rack, or filter immediately
Extended contact time may reduce protein-fining effect at warmer temperatures.
Addition just prior to cold stabilizing helps to compact very bulky bentonite lees.

Problems:
Bulky, loose lees 5-10% wine volume.
Growing resistance to waste water contamination with bentonite
No BATF limit - GRAS

Casein:

Preparation:
Kolorfine: Dissolve 1 lb in 2 gallons water (6% solution), stir 2-3 hrs.
Vinpur: None, added as a powder

Use:
White wines:
Slowly dose desired amount into wine, stir 20-30 minutes.
Follow with silica dioxide (Kieselsol, Nalco)
Allow to settle, rack, or filter immediately.
Red Wines:
May be used to soften tannins
Used without other tannin or silica dioxide preparations

Problems:
Impure grades of casein will cause off odors/flavors.
Test each batch in wine before using.
No BATF limit (GRAS)

Copper Sulfate

Characteristics:
Removes Hydrogen Sulfide (H_2S) which masks varietal character at low levels, and stinks of rotten egg to rubber boots at hi levels.
Copper sulfate solution is a blue liquid. Copper reacts with H_2S forming CuS (copper sulfide), which precipitates. Excess copper stays in solution in wine.

Preparation:

Purchase as a 1% to 10% wt/vol solution of $CuSO_4 . 5H_2O$

Finer Filter product, Sulfex, added as a slurry, must be filtered

Use:

1% copper sulfate solution: added directly to wine with gentle stirring.

Problems:

Potential to have excess copper in wine - haze formation, toxicity

Wine should be sent to lab for copper analysis after these treatments, especially at higher use levels.

Copper levels in wine above 0.3 ppm may cause haze problems

Addition of 2 gm of $CuSO_4.5H_2O$ /1000 gal raises copper content of wine by 0.1ppm

BATF limit: 10 gm copper sulfate/1000gal. May not have residual copper in excess of 0.2 ppm.

Gelatin

Characteristics:

- ✓ Protein material produced from collagen extracted from animal skin & bones
- ✓ Purchased as a granular powder which must be dehydrated, or as a liquid
- ✓ Modifies overly astringent wines by reacting with tannins
- ✓ Used for clarification of white and red wines
- ✓ Less damaging to young wine color, bonds with larger polyphenols and can lighten older wine color
- ✓ Gelatin is rated by bloom (refers to the gelatins' ability to absorb water) - lower bloom is more active, higher bloom settles more rapidly.
- ✓ Must use same bloom for trials as for final treatment

Preparation:

- ✓ Hydrate dry gelatin by stirring 75 grams into 1 gallon hot (200F) water until dissolved

Use:

Add desired volume of warm liquid solution very slowly to cool (<50 F) wine while stirring constantly.

White wine must be pretested with tannic acid at 1:1 wt/wt ratio 24 hours before gelatin addition, or counter fined with colloidal silica at 1:7 ratio, (1 lb gelatin/M wine counter fined with 7 lbs silica solution/1000 gal)

Problems:

Loss of color in red wine treatment, potential for protein instability in white wines.
No BATF limit (GRAS)

Isinglass

Characteristics:

- ✓ Protein material prepared from air bladder of sturgeon fish
- ✓ Commercial product, Drifine, is a free flowing fine powder
- ✓ Used as a riddling aid in sparkling wine production
- ✓ White wines, used to unmask fruit aromas and soften harshness
- ✓ Excellent clarifying agent for white wines, especially after barrel treatment
- ✓ Less stripping effect than gelatin, casein, etc.

Preparation:

- ✓ Mix 2 grams Drifine in 1 liter cool (10C) water (0.2% solution) with vigorous stirring
- ✓ Let stand 20 minutes, stirring occasionally to make a homogenous, opalescent solution

Use:

Add to wine <25C with active stirring.
May be counterfined with bentonite or silica solution (1-3 lbs/M rate for both) to help reduce lees & speed settling.

Problems:

Fairly expensive, potential for fishy off odors if stored too warm, or too long.
Soft, thick lees, can clog filters

PVPP:

Characteristics:

- ✓ Polyclar AT, polyvinylpolypyrolidone, synthetic, protein-like material
- ✓ Does not cause protein instability
- ✓ Supplies as a fine granular powder
- ✓ Specific bonding activity toward low molecular weight phenols
  - o Catechins (precursors to browning & bitterness)
  - o Leucoanthocyanins (pinking precursors)
- ✓ Effective in helping settle carbon

Preparation:

- ✓ None, added as granular powder directly to wine.

Use:

Add as dry form, or 5-10% slurry prepared in wine or water, with constant stirring for 30 minutes. Allow to settle, rack, filter.

Problems:

May strip color and complexity
Wine must be filtered after addition (BATF rule).
BATF limit - 6.7 lbs/1000 gal.

Silica, Colloidal Solution:

Characteristics:

- ✓ Kieselsol, & Nalco 1072 – proprietary name for aqueous suspension of silicon dioxide
- ✓ Used in white wines in connection with gelatin and bentonite
  - o Help to settle gelatin and other protein fining agents quickly
  - o Keeps gelatin from causing protein instability in wine
- ✓ Used with bentonite, it may reduce the amount of bentonite needed for protein stability
- ✓ Does not damage wine aroma, flavor, or color

Use:

Added to wine, usually after gelatin addition, 7 times weight of gelatin added
Gentle stirring during addition. Allow to settle.

Problems:

Will not flocculate and settle unless sufficient protein is present. Lab trials extra important here.
2 year shelf life
Freezing destroys product activity.
Must be filtered out (BATF rule)
BATF limit - 20 lbs of kieselsol/1000 gal.

Sparkolloid/Klear-Mor

Characteristics:

- ✓ Polysaccharides, alginates, extracted from marine brown algae, bound to diatomaceous earth
- ✓ White granular material
- ✓ Principal action is to clarify by clumping and settling particulate matter
- ✓ No other effect on wine at low levels

Preparation:

Add Hot Mix Sparkolloid/Klear-Mor slowly to hot (180F) water
rate of 1 lb to 2 gallons water (6%)
vigorous, continuous stirring for 15-20 minutes.
Must keep hot and stir often until use
Homogenous, tan slurry, which gels on cooling.
Loss of activity if remelt solidified gel

Use:

Add hot solution to wine while stirring.
Allow to settle a few days to several weeks
Often added soon after bentonite addition, as wine is moved to cold stabilization.
Rack and filter.

Problems:

Difficult preparation of large volumes.
✓ Very fluffy, hard to settle lees.

Summary of Considerations in Wine Fining:

ALWAYS DO LAB FINING TRIALS BEFORE TREATING WINE!
Prepare lab trial material exactly like final material
Run tests at same temperature as bulk wine
Use smallest quantity, purest quality materials
Limit contact to minimum time needed to produce results
Mix thoroughly and for proper amount of time after additions
NEVER COMBINE DIFFERENT FINING MATERIALS BEFORE ADDING TO WINE!

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INFLUENCE OF TRAINING SYSTEM ON SHIRAZ GRAPES IN THE BAROSSA VALLEY

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Introduction

My input on this project came about as an interest in pursuing a Sabbatic Leave in South Australia. The research project had been established in the early nineties, and data had been collected by different individuals and groups commencing with the 95-96 growing season. By way of acknowledgment, I am indebted to Drs. Peter Dry and Patrick Iland of the University of Adelaide, Waite Campus, for helping me to realize this opportunity.

Project objectives were to test several hypotheses related to the impact of Shiraz vine training on fruit quality in the Barossa:

highest fruit quality is derived from canopy training that promotes *moderate* fruit exposure;

sparse to moderate canopy density, as influenced by vine vigor, facilitates moderate fruit exposure

fruit quality is more affected by crop yield than by readily measured canopy characteristics

The commercial objective was straightforward: To identify the most efficient training system to realize the goal of producing acceptable fruit quality with minimal labor.

Materials and methods:

The experiment was conducted in Orlando-Wyndham's "Gramps" vineyard in the Barossa Valley, South Australia. Vines were own-rooted Shiraz, which had been planted in 1993 to north-south-oriented rows. Vines were spaced 1.50 m apart in 2.75-m wide rows. Water is limited at the site and the vine size would be considered small to moderate, by eastern US standards (Table 1).

Treatments: Except for minimally-pruned vines (MP), training systems were imposed from the onset, and included:

Vertically Shoot Positioned (VSP): Vines were trained to bi-lateral cordons, horizontally positioned 1.0-m above the ground, and annually spur-pruned. Shoots were positioned vertically upright with the aid of movable foliage catch wires to promote a relatively thin curtain of foliage.

Single Wire (SW): Considered our "standard" because of its common use in low-vigor Barossa vineyards; vines were trained to bi-lateral cordons, horizontally positioned 1.0 m above the ground, and annually spur-pruned. Unlike VSP, no shoot positioning was done and the developed canopy, viewed cross-sectionally, formed an irregular circle.

High Single Wire (HSW): Same as SW, except the cordons were positioned 1.8 m above the ground.

Scott-Henry (SH-UP and SH-DOWN): Alternate vines were shoot-positioned upwards and downwards to relatively thin, vertical canopies. In either case, shoots originated from 3.0-m long, bi-laterally-trained cordons situated ~ 0.8 m (downwards-trained), or ~ 1.0 m (upwards-trained) above ground.

Minimally-pruned (MP): Same as SW, except vines were not annually spur-pruned. Instead, dormant vines were skirted approximately 0.5-m above ground. The summer canopy appeared as a denser version of the SW, with many small shoots borne towards the exterior of the canopy. The MP treatment was initiated in the second season by sacrificing some SW treatment replicates.

Experimental design: Treatments were arranged in a randomized, incomplete block design that consisted of nine replicates each for VSP, HSW, and SH-(UP and DOWN). Four of the nine replicates included SW, while the remaining five included MP.

Vineyard management: Vineyard management was comparable to that used commercially in the area and included use of a winter green cover which was disked-in immediately prior to bud break, and pre-emergence herbicide application under the trellis. Vines were drip-irrigated up to 1 $ML \cdot ha^{-1}$. Pest management typically consisted of several fungicide applications, primarily for powdery mildew.

Study period: Treatments were imposed and data collected for five seasons, starting with the 1995-1996 season. Due to changes in research personnel, the manner in which treatment effects were measured, and the nature of data collection varied somewhat from year to year. The methods used and results obtained during the 1999-2000 growing season are largely representative of techniques and results obtained in previous years.

Canopy descriptors: Counts and measures were made of (1) shoots per vine, (2) leaf area per vine, (3) canopy light penetration, (4) bunch exposure, and (5) leaf layers [point quadrant analysis].

Berry sampling and general fruit harvest: Berries were sampled (100 berries/treatment rep) on 12 and 23 February, and on 1, 8, and 13 March. These samples were used to derive single-berry weights, soluble solids concentration, pH and total titratable acidity. Fifty-berry subsamples were used to determine fruit color (anthocyanins; absorption at 520 nm) and phenolics

(absorption at 280 nm).

Harvest: Fruit of each treatment rep was harvested by vine on 13 March to obtain counts of clusters per vine and crop weight per vine, from which average cluster weights were derived.

For all of the above, separate measures, samples, and harvest data were obtained from the two separate Scott-Henry (SH-Up and SH-Down) canopies.

Results:

Long-term yield data are provided in Table 2. The SW system was the "standard" used at this vineyard. Yields of SW-trained vines averaged 3.2 kg/m over the 5 years of record, or about 6 tons/acre. The SW long-term yields were comparable to yields of the VSP and HSW systems. MP-trained vines averaged 4.4 kg/m of canopy (about 7 tons/acre), but was as high as 7.1 kg/m (11.5 tons/acre). Fruit quality suffered with those high crop levels (data not shown), but was acceptable at the more moderate (5 to 6 tons/acre) levels. One limitation with MP-trained vines is their propensity for over-cropping, particularly in initial years of production. While there are means of reducing crop on MP-trained vines, that was not done during the course of this work. The Scott-Henry trained vines averaged 3.9 kg of crop per unit length of row (canopies combined), making them somewhat more productive (on a per unit length of row basis) than the single canopy training systems; however, much more work is required in terms of canopy management with SH vines.

Results of the 2000 harvest:

Yield components: MP-trained vines were associated with the smallest berries (0.8 g) and the fewest berries per cluster (40) of all training systems (Table 3); however, because of the greater number of shoots and clusters per vine, the crop per meter of canopy was superior to all systems but the VSP. Other interesting aspects of yield components include the relatively low number of clusters per shoot with MP and SH-downward trained vines, relative to other training systems. For all systems, the leaf area to crop ratio was much greater than that minimally recommended (about 12 cm^2/g of fruit).

Fruit quality: A SSC of 24 ± 0.4 °Brix was used to represent the average maximum sugar accumulation achieved by each training system. That sugar level was achieved first by the "standard" (SW) training system on 1 March, by HSW and SH-up on 8 March, and by remaining systems on 13 March (Figure 1). The relative pattern of sugar accumulation among treatments seen at the first sample date generally remained consistent at subsequent samplings (Figure 1). The rate of sugar accumulation appeared to be inversely related to crop level (Table 3). For example, the VSP and MP systems carried the largest crops (but not "overcropped"), and were delayed, relative to SW, in achieving 24 °Brix. The Scott-Henry lower canopy (SH-Down) deviated from the above relationship in that it had a light crop (1 kg/m of canopy) yet was consistently retarded, compared to SW, in sugar accumulation. It is unclear why the SH-down

fruit was retarded in sugar accumulation as leaf area to fruit ratios were actually higher with the lower canopy than for the upper (Table 3) and light levels (on 29 January) were not greatly different between the canopies (Table 4). It is possible that the lower canopy suffers from lower light levels on a seasonal basis – that is, the cumulative trend towards lower light interception on the lower canopy. That was not measured in this work.

Fruit pH was generally not affected, with the exception that fruit from the lower canopy of Scott-Henry averaged 0.1 pH units higher than the upright-directed canopy on each of the last two sample dates (data not shown). Thus, while the lower-directed canopy fruit did, ultimately, ripen to 24 °Brix, it did so at a "cost" of higher pH, and lower crop yield. The Scott-Henry upper canopy showed the slowest increase in fruit pH with sample date.

Fruit color and phenolics: Anthocyanin content (mg/berry) and concentration (mg/g berry fwt.) varied little among treatments when all samples were evaluated at 24 ± 0.4 °Brix (Table 5). While SW had greatest color *content* (mg/berry) at this point, the relatively large berries (owing to earlier [1 March] sample) meant that color *concentration* (mg/g berry fresh wt.) was no different than MP, VSP, or Scott-Henry. Phenolics, like anthocyanins, varied little between treatment; highest concentrations were found with the MP vines, which did not differ significantly from the Scott-Henry or HSW vines (Table 5).

A basic question can be asked, What is the more influential determinant of color concentration and content of fruit? Crop level or fruit exposure? Fruit phenolics and color (anthocyanin) concentrations showed linear decreases with increasing crop per meter of canopy (Figure 2). While the relationship was significant, the model explained less than one-fourth of the variation in total anthocyanins when applied to all training systems except MP and SH-Down. The relationship with MP and SH-Down was non-existent. Regressing fruit color on fruit exposure showed a significant, linear increase in color with increased exposure (data not shown). Here too, the type of training system affected that relationship.

Canopy characteristics: Shoot counts revealed that VSP- and HSW-trained vines had a similar shoot density of about 34 shoots per meter of canopy (Table 3). That density was somewhat greater than that of the SW, and Scott-Henry upper and lower canopies. Canopy point quadrant measures were confined to the training systems that used shoot positioning and showed that VSP canopies had less fruit exposure than either of the Scott-Henry canopies (data not shown). The relatively poor cluster exposure of VSP was reinforced by exposed cluster counts and by PAR readings (Table 4). VSP training also resulted in relatively few clusters obscured by no or only one leaf as assessed via the bunch exposure index (Figure 3). And, by that method, more of the VSP clusters were apt to be obscured by two or more leaves, compared with the MP or Scott-Henry canopies. Thus, VSP was the least efficient training system in terms of exposure of clusters to sunlight; confining 30+ shoots/m of canopy to a thin, vertical canopy simply resulted in excessive cluster shading.

Summary: All training systems, with the possible exception of VSP, gave acceptable and comparable fruit quality as judged by color concentration at 24° Brix. The color response was, to

some extent, governed by crop yield. The contribution of cluster exposure to color development is more complex; however, the general pattern was one of increasing color with increased cluster exposure.

The yield response would suggest that HSW and SW produce lower crop yields than other treatments (Scott-Henry canopies combined). In terms of efficiency of production, both HSW and SW require less labor than do the VSP and Scott-Henry systems, thus the somewhat lower yields may still make HSW and SW more profitable. VSP ultimately achieved acceptable harvest quality, but again, the system requires more manual labor than do the HSW and SW. Minimally pruned vines had acceptable yields and very high fruit quality in the 1999-2000 growing season. The potential for overcropping exists, however, as seen with previous seasons' yields.

Training systems must be evaluated in light of the growing conditions (water and sunshine availability) and vine vigor produced under unique situations. If these training systems were conducted under the more humid growing conditions of Ohio, much different results could be expected.

Table 1. Cane pruning weights of Shiraz vines following the 1999-2000 growing season.

	Cane pruning
Training[z]	wt. (lbs./vine)[y]
VSP	2.18 b
HSW	2.60 a
SW	2.51 a
MP	Not pruned
SH-down	1.47 c
SH-up	2.53 a

[z] See text for description of training system.
[y] Means followed by the same letter are not significantly different at $P < 0.05$ level.

Table 2. Shiraz crop yield by training system (kg/m of canopy) over five growing seasons.

Training	95-96	96-97	97-98	98-99	99-00
VSP	3.6 ab	3.7	2.0	5.4	* 3.7 a
HSW	3.0 b	3.7	1.8	5.2	**2.5 bc
SW	3.8 a	2.1	3.0	4.3	2.7 b
MP	.	4.7	6.9	7.1	3.2 a
SH-down	1.7 c	1.5	1.6	>6.0	1.0 d
SH-up	2.2 c	2.2	1.8		2.2 c

* 3.7 kg/m = 6.6 tons/acre

** 2.5 kg/m = 4.5 tons/acre

[z] See text for description of training system.

[y] Means followed by the same letter are not significantly different at $P < 0.05$ level.

Figure 1. Soluble Solids accumulation (vertical axis) in Shiraz during the 1999-2000 growing season as a function of training system and date of sample (horizontal axis).

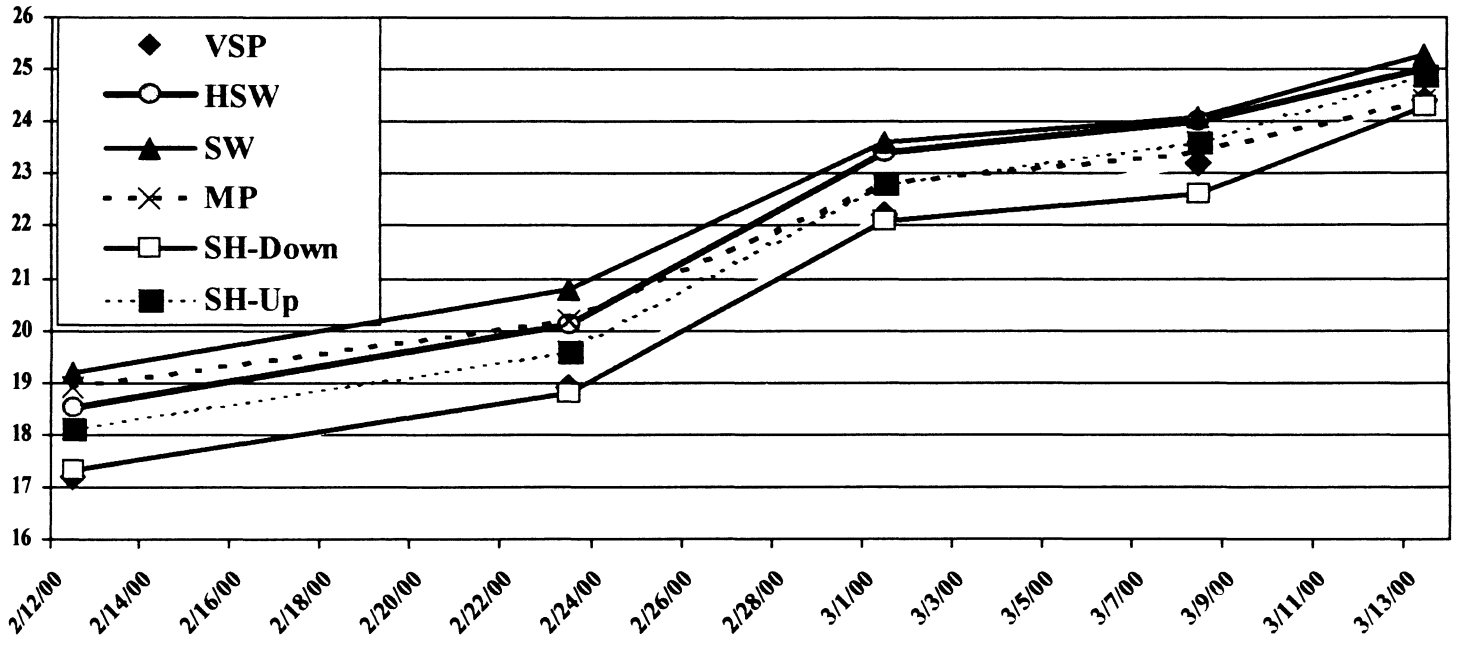


Table 3. Components of crop yield associated with Shiraz training system at harvest on 13 March 2000.

	VSP	MP	SW	HSC	SH-UP	SH-Down
Shoots/vine	51 d	242 a	49 d	52 d	83 b	70 c
Clusters/vine	70 c	170 a	61 c	65 c	100 b	55 c
Clusters/shoot	1.4 a	0.7 c	1.2 ab	1.3 ab	1.2 b	0.8 c
Ave. cluster wt (g)	78.2 a	32.9 d	69.3 b	56.8 c	66.2 b	55.7 c
Ave. berry wt (g)	1.03 b	0.81 f	1.05 a	0.97 d	0.99 c	0.92 e
Berries/cluster	76 a	40 e	66 bc	58 d	67 b	60 cd
Crop (kg)/vine	5.5 b	4.8 bc	4.3 cd	3.8 de	6.7 a	3.1 e
Crop/m of canopy	3.7 a	3.2 a	2.7 b	2.5 bc	2.2 c	1.0 d
Crop/m of row	3.7	3.2	2.7	2.5		3.2
Leaf area (cm^2)/g of crop	23.6 d	65.9 a	25.8 cd	34.2 c	27.6 cd	44.2 b

Table 4. Fruit zone Photosynthetically Active Radiation (PAR) as measured on 29 January, 2000 and bunch exposure as assessed by counts of clusters that were wholly or partially exposed to the canopy surface on 9-10 February.

Treatment	Percent (of ambient) PAR	Percent exposed clusters
VSP	5.3 c	37.6 b
HSW	12.9 b	70.8 a
SW	12.8 b	68.6 a
MP	22.6 a	65.2 a
SH-Down	14.7 b	.†
SH-Up	15.4 a	.†

† Exposed cluster data were collected by panel; however, yield data were collected by vine.

Table 5. Training system effects on Shiraz soluble solids concentration (SSC), berry weight, total anthocyanins (abs. 520nm) and total phenolics (abs. 280nm) with fruit assessed at approximately 24 °Brix, irrespective of harvest date (1 March to 13 March).

Treatment	SSC (orix ±SE)	Berry wt. (g ±SE)	Total anthocyanins (mg/berry)	Total anthocyanins (mg/g berry fwt)	Total phenolics (mg/berry)	Total phenolics (mg/g berry fwt.)
VSP	24.42 ± 0.19	1.02 ± 0.04	1.12 b	1.10 c	1.12 cd	1.09 c
HSW	24.00 ± 0.21	1.06 ± 0.04	1.29 a	1.22 a	1.27 ab	1.21 ab
SW	23.63 ± 0.18	1.16 ± 0.03	1.30 a	1.12 bc	1.36 a	1.17 b
MP	24.40 ± 0.54	0.82 ± 0.09	0.99 c	1.20 ab	1.02 d	1.26 a
SH-Down	24.33 ± 0.16	0.95 ± 0.05	1.14 b	1.21 ab	1.14 c	1.22 ab
SH-Up	23.61 ± 0.23	1.01 ± 0.06	1.17 ab	1.16 abc	1.20 bc	1.20 ab

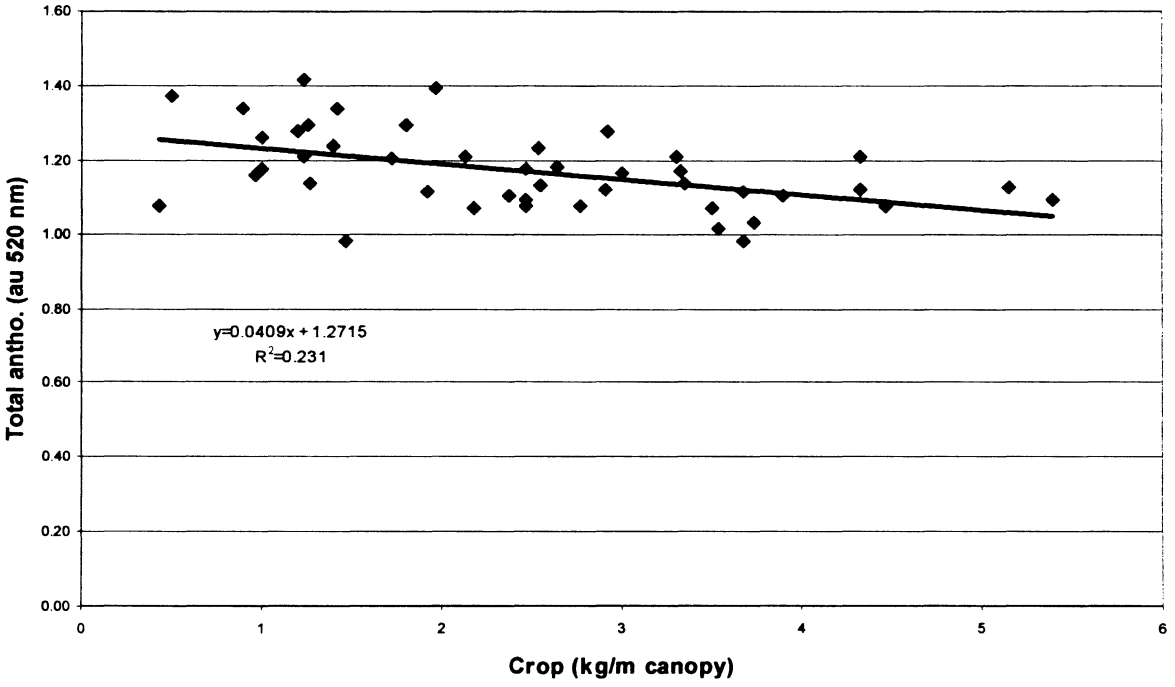
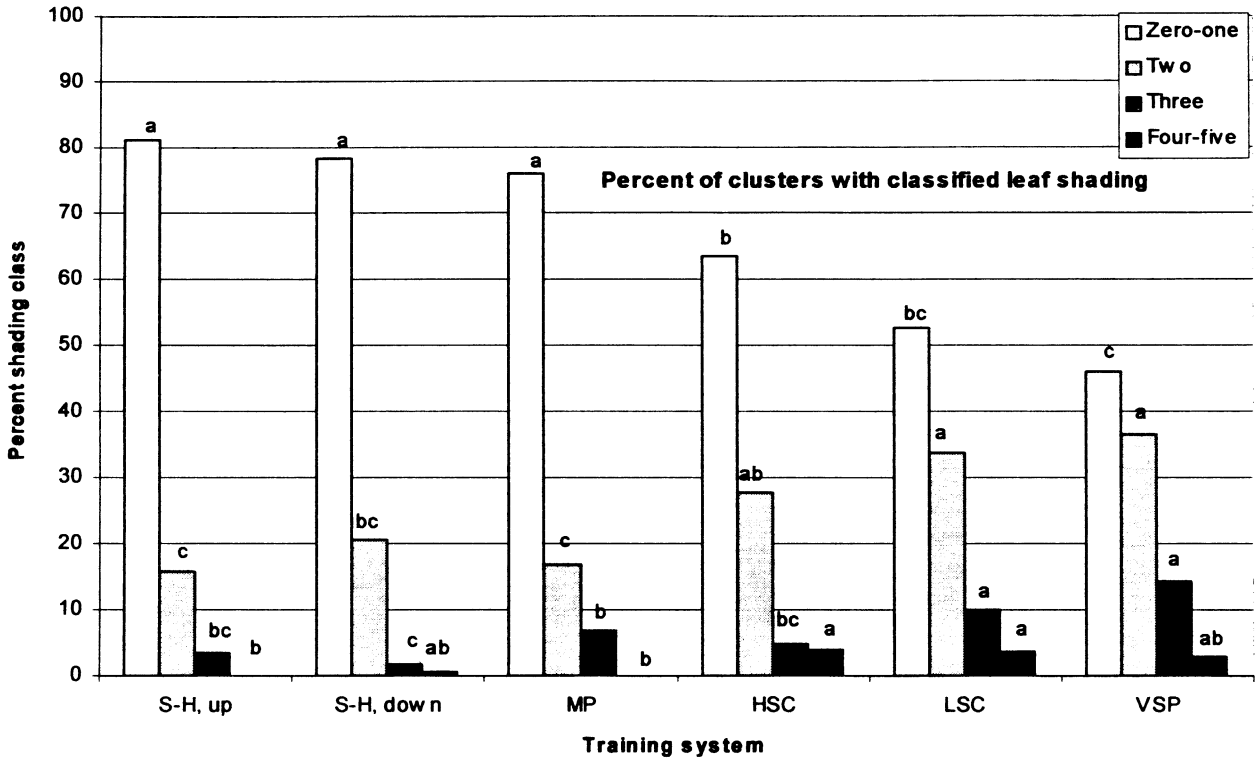


Figure 2. Total Anthocyanins plotted on crop per meter of canopy (all treatments except MP and SH-Down).

Figure 3: Percentage of clusters that fell within each of four leaf shading classifications: zero or one leaf, two leaves, three leaves, and four or five leaves. Bars, of a given leaf shading classification, that bear different letters, are significantly different at $P < 0.05$. ANOVA conducted on square-root-transformed data, but presented as untransformed percentage data.



DRAINAGE IMPACT ON VINES

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Chalet Debonne Vineyards

Soil in Chalet Debonne Vineyard, Madison, OH, near Lake Erie is of the Platea silt loam series and formed on a Wisconsin glacial till plane with sediments of clayey shale and siltstone (USDA Soil Conservation Service, 1973). Platea silt loam contains 22-34 % clay and fragipans can be found from 14.17-25.98 inches (36-66 cm) below the soil surface (USDA Soil Conservation Service, 1973; Zucker and Brown, 1998). This soil series has poor internal drainage during periods of high precipitation and it has been classified in the drainage group E-4 (USDA Soil Conservation Service, 1973). Soils that are composed primarily of clay and silt are more prone to poor infiltration and percolation than soils with a high sand content.

Soil compaction can readily occur during wet periods in which soils are often at field capacity when growers use heavy spray equipment in the spring or remove fruit at harvest. As equipment repeatedly passes over the same area in vineyard there is a greater potential for soil bulk density to increase. Few grape growers implement some type of drainage program to encourage drainage and lower the water table to enhance trafficability of equipment in fields. Vine vigor and productivity have been shown to improve by the use of field tile in Ontario, Canada (Fisher, 1997). An increase in plant vigor appeared to be related to improved soil drainage and possibly due to an increase of oxygen in the root zone. In an attempt to determine what caused the distinct difference in vine growth, a study was established to evaluate the differences in the vines and soil immediately over the tile lines and vines and soil in the center between the lines. A separate study was conducted in the 'Pinot Gris' and 'Chambourcin' vineyards, which were adjacent.

The vineyard site at Chalet Debonné Vineyards was tiled with diagonal laterals to the field edges (USDA Soil Conservation Service, 1973) in 1992 using 4-inch (10-cm) diameter tile spaced 40 ft (12 m) apart. 'Chambourcin'/Couderc 3309 (3309C) (planted in 1995) and 'Pinot Gris'/Couderc 3309 (3309C) (planted in 1994) grapevines from Chalet Debonné Vineyards at Madison, Ohio were used in this study. Grapevines were selected according to their position to tile lines, and they were either over a tile or midway between two lateral tiles. All grapevines were trained to a low cordon (30 in (76 cm) from ground) and vertically shoot positioned. One-year-old canes were pruned to three to four nodes/spur.

Vine growth and production were measured by weighing live and dead one-year old wood from 'Chambourcin' grapevines grown over tile were not significantly greater than vines not located near a tile (Table 1). 'Pinot Gris' grapevines grown over tile had a significantly higher amount live and dead pruning wood than vines not tiled (Table 1). Live and dead pruning wood were higher for both cultivars in 1999 than in 1998.

Yield of 'Chambourcin' was also significantly greater on grapevines grown over tile compared to vines not located near tile. Cluster weight of 'Pinot Gris' was higher in 1999 than in

1998. Yield in 1999 was higher for both cultivars compared to 1998 and proximity to the tile line had no effect on yield in 1999. Tiling significantly increased the berry weight in 'Chambourcin', but had no significant influence on 'Pinot Gris' berry weight. In the study conducted by Fisher (1997) yields in tiled areas were greatly increased over nontiled areas. Vine growth and productivity increased in response to tiling in poorly drained field more so than in well-drained fields. This study supports the results found by Fisher (1997) that it is important to remove excess water from the soil profile to improve vine productivity.

The significant differences in 1999 and 1998 data could be attributed to the time required for the vines to recover from the 1996-97 wet conditions (Fig. 1) and subsequent winter damage. By 1999, most of the vines were reestablished on the trellis.

Juice made from 'Chambourcin' and 'Pinot Gris' did not differ in total soluble solids (TSS), pH, and titratable acidity (TA) when comparing tiled versus non-tiled grapevines (Table 1). Soluble solids and TA of 'Chambourcin' fruit were higher in 1998 than in 1999, which was likely due to the lower crop in 1998. No significant differences were found in pH of 'Chambourcin', however pH of 'Pinot Gris' fruit was significantly greater in 1999 than 1998 (Table 1). In this study, fruit composition was more influenced by growing season and crop level than by soil moisture. Environmental factors including sunlight, temperature, and rainfall probably had a greater impact on fruit quality than the soil moisture content.

Soil in the 'Chambourcin' and 'Pinot Gris' vineyards showed a significant decreasing linear relationship in pH with depth of the soil profile. There was no difference between the pH of the control soil sample and the sample taken over the tile lines in the 'Chambourcin' vineyard. In the 'Pinot Gris' vineyard, however, pH of the soil that had been mixed when the tile was installed was higher than the pH of the undisturbed soil between tile lines. The soil in the 'Pinot Gris' vineyard was less acidic overall than the 'Chambourcin' vineyard. There was no interaction between tillage and soil depth.

Relative water content (RWC) in the 'Chambourcin' vineyard decreased down through the soil profile. However, RWC in the 'Pinot Gris' vineyard was higher at 12 in (30 cm) than at either 6 or 18 in (5 or 45 cm). Since the Platea soil is known to have fragipans, these impervious layers may have reformed after the tile lines were established resulting in an increase in % relative water content at 30 cm. There was no significant difference in soil relative water content between tiled versus non-tiled soil in either vineyard, which indicated that there was no evident tiling affect on soil drainage or water holding capacity. However, this likely was very different in 1996 with the very wet conditions and the tile would result in facilitating removal of excess water from the soil profile.

Soil compaction as measured by penetrometer was significantly greater in the equipment track than in the soil around the plants in both vineyards, except at the 20cm level in the 'Pinot Gris' vineyard where there was no significant difference (Table 2). Track and aisle compaction were significantly different at each soil level, except for the 2, 14, and 16 in (5, 35, and 40 cm) levels in the 'Chambourcin' vineyard, and the 14- (35 cm) and 16-in (80 cm) levels in the 'Pinot

Gris' vineyard. These results would support the concept that repeated passes of equipment through the vineyards caused increased soil compaction in the track area. The compaction could severely reduce water percolation through the soil profile in the tracks. When considering the entire soil profile in the plant area, there does not appear to be a problem with compaction (Table 2). Tiled areas tended to dry much quicker than nontiled following heavy rains and this was also the case in the study conducted by Fisher (1997). Well-drained soils will undoubtedly provide greater trafficability when producers are spraying in early spring and harvesting in the fall.

Soil over the tile lines had higher soil oxygen levels than soil in between tile laterals. No significant difference was found between the oxygen levels in soil of the 'Chambourcin' and 'Pinot Gris' vineyards. Oxygen levels were higher at the 6 in (15 cm) level than at the 18 in (45 cm), but the differences were not significant. The significant increase in the amount of oxygen that was found in the root zone of the vines grown over tile may have provided an important component in vine survivability. Since soil aeration is important for good root growth, the significant increase in oxygen of tiled soils may have increased root system growth of vines grown over tile.

Conclusion

Vines that grew very poorly following the excessively wet year of 1996 recovered by 1999. The diagonal pattern observed in 1997 was no longer visible in 1999 and vines over tile and between tile lines had similar yields. Prior to our study, it was postulated that by inserting the tile, either soil compaction or soil pH had been altered and could be responsible for the vine performance. Measurements indicated that these factors were not altered enough to explain the growth differences. It does appear that soil oxygen was improved by tiling and this was likely much greater in the excessively wet year resulting in improved vine growth. Although this vineyard is an excellent grape site because of its proximity to Lake Erie with its moderating effect on temperatures, the heavy clay soil caused a problem in vine growth, especially in very wet years. Thus, it appears prudent on soils of this type, tile drainage is beneficial to vines immediately over or adjacent to the lines and spacing of the laterals needs to be closer than 40 ft normally recommended to adequately protect vines in wet years.

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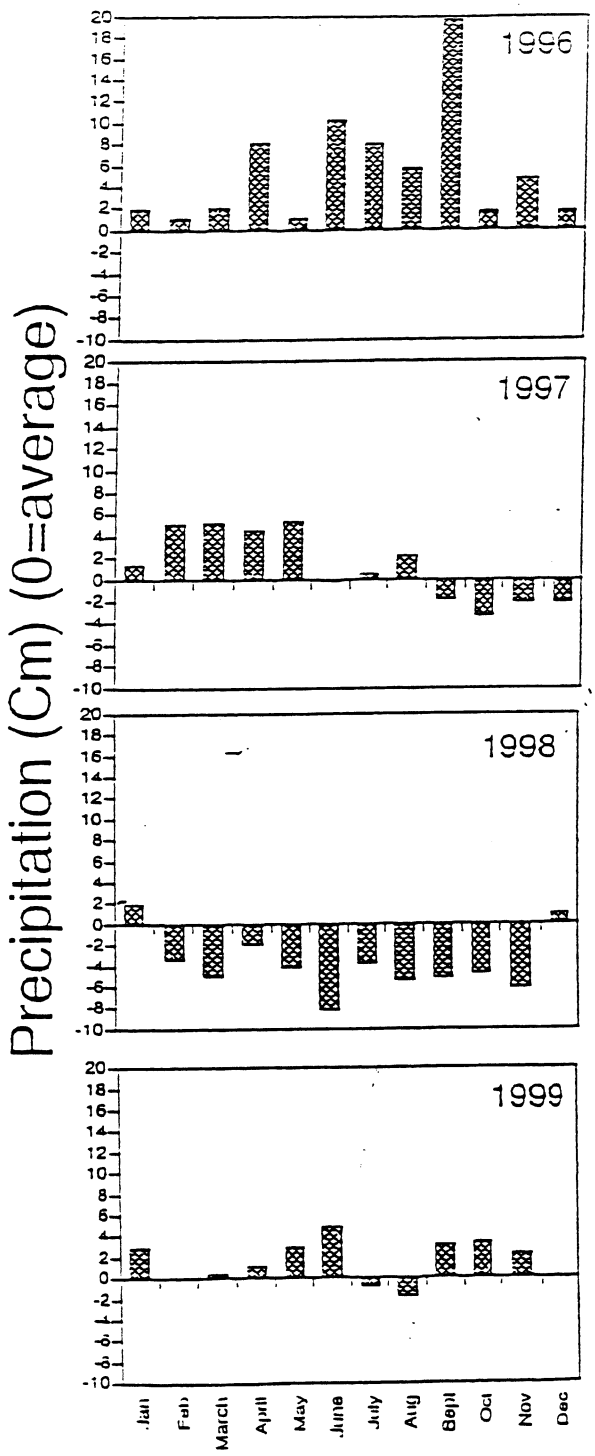

Figure 1. Monthly precipitation 1996 through 1999 compared to the long time average for northeastern Ohio; 2.5 m = 1.0 inch.

Table. 1 Influence of tiling on yield, cluster size, berry weight, and fruit chemical analysis of 'Chambourcin' and 'Pinot Gris' at Chalet Debonné Vineyards in 1998 and 1999.

	Pruning[z]					Fruit composition		
	Live wt. lb	Dead wt. lb	Average Cluster wt. lb	Yield lb/vine	Berry wt. (g)	TSS[y] (%)	pH	TA[x] (g L^{-1})
'Chambourcin'								
Treatment								
Non-tile	1.04	0.07	0.37	27.3 b	1.90b	20.7	3.14	10.4
Tile	1.62	0.10	0.42	37.2a	2.10a	20.7	3.14	10.4
Year								
1998	0.94b	0.03b	0.34b	20.7b	2.03	22.0a	3.17a	11.1a
1999	1.72a	0.13a	0.45a	44.6a	1.97	19.4b	3.10b	9.8b
'Pinot Gris'								
Treatment								
Non-Tile	0.53b	0.03b	0.20	19.9	1.45	17.8	3.33	06.0
Tile	1.04a	0.07a	0.20	22.3	1.50	18.4	3.29	06.2
Year								
1998	0.32b	0.03b	0.19b	15.6b	1.68a	18.7	3.28b	06.2
1999	1.25a	0.07a	0.22a	26.6a	1.27b	17.5	3.35a	06.1

[z]Data followed by different letters are significantly different at LSD $P \leq 0.05$.

.[y]Total Soluble Solids

[x]TA = titratable acidity % tartaric acid.

[w]28.35 g = 1.0 oz, 1.00 lb = 0.454 Kg, 1.0 gL^{-1} = 1000 ppm

Table 2. Soil penetrometer values (lbs/in^2) in 'Chambourcin' and 'Pinot Gris' vineyards at Chalet Debonné Vineyards comparing the effect of tiling and location relative to the vine.

	Pentrometer values in lb/inch^2 at 2-inch intervals of soil depth								Average compaction
	2	4	6	8	10	12	14	16	
'Chambourcin'									
Treatment									
Non-tile	177	181	212	218	249	340	507	630	314
Tile	245	231	269	256	234	380	517	583	356
	NS	NS	NS	NS	NS	NS	NS	NS	NS
Location									
Plant	117b	113b	156b	166b	201b	286b	406b	507b	244b
Track	243a	349a	343a	351a	493a	512a	601a	633a	439a
Aisle	223a	165b	222b	193b	229b	283b	528a	688a	313b
'Pinot Gris'									
Non-tile	206	207	217	176	210	306	429	514	283
Tile	158	178	188	196	221	271	368	448	283
	NS	NS	NS	NS	NS	NS	NS	NS	NS
Location									
Plant	103b	77b	147b	179ab	156b	176b	199b	305b	168c
Track	271a	363a	341a	270a	339a	446a	494a	545a	384a
Aisle	171b	139b	120b	108b	152b	242b	502a	593a	253b

[z]Data followed by different letters are significantly different LSD at $P \leq 0.05$.

[y]1 inch = 2.54 cm; 1 lb/in^2 = 6.89 Kpa.

SETTING UP A WINERY FOR BASIC MUST AND WINE ANALYSIS

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When setting up a wine laboratory, one must not underestimate the importance of a proper equipped laboratory. The wine laboratory is one of the most important places in the winery. To produce an "award winning wine" it is essential that you utilize the wine laboratory to its fullest potential. By not paying special attention to your basic wine analysis is relative to buying a BMW sports car and never changing your oil. Sooner or later this will come back to hurt you. If you put so much time, effort and money in your winery why would you not be properly equipped with a well thought out wine analysis lab. There are several important factors to consider when setting up a properly equipped laboratory.

ROUTINE ANALYSIS

Before we make any decisions about the physical size and location of the wine laboratory, we need to determine what basic must and wine analysis procedures are necessary to produce a quality wine. This will help us in later decisions as to the overall size, shelf space, storage and special needs based on specific laboratory procedures.

Soluble Solids: Knowledge of the sugar content is important to the winemaker in determining the maturity of the grapes, the amount of amelioration needed, the approximate alcohol content and the completeness of fermentation. Soluble Solids content are measured using a Brix (Balling) hydrometer that measures the density of an aqueous solution. The Brix (Balling) hydrometer is calibrated in degrees corresponding to percent of sucrose in water at 20°C (68 °F) or grams of sucrose per 100 grams of water at 20°C. As fermentation proceeds there is an increase in ethanol. Since ethanol is less dense than water most finished dry wines will have a negative Brix (Balling) reading. To determine accurate residual sugar readings after fermentation you would have to utilize another procedure.

pH and Total Titratable Acidity: Acid levels significantly influence wine pH that usually falls between 3.2 to 3.7 on a pH scale. Monitoring pH is important to help determine ripeness of the grape; color stability of must and wine along with chemical and microbial stability. The major acids present in wine are tartaric and malic acid. Acids are responsible for the fresh crisp taste of wine. Wines with low acid content appear to be "flat" and insipid. Wines with too much acidity appear to be very tart and puckery. Orange tinted rose's and brownish purple red wines may indicate wines with a high pH and low acidity. As wine pH decreases towards 3.0 the color of our rose's and red wines will become a brighter pink and a deep richer red. Wine stability will also benefit from a lower pH. As the pH increases towards 4.0 we have a serious threat for microbial growth. Therefore we can see importance to monitor our pH and acid levels properly. Detailed analysis will give us the basis for determining any chemical additions needed to be made to the must or wine to affect our pH and acid levels in achieving proper quality control. Wine pH can be

measured using a pH meter accurate to .01 pH units. I would recommend a benchtop meter with a minimum two point calibration and able to read in both pH and mV modes. Total Titratable Acidity is determined by a direct titration procedure. The wine acids are titrated with a standardized sodium hydroxide solution to a phenolphthalein endpoint.

Sulfur Dioxide: As we analyze the Ohio wine industry from an extension point of view at The Ohio State University, if there is one vital compound for our wine industry to utilize in making high quality wines would be through the proper use of sulfur dioxide. Sulfur dioxide serves three major functions in winemaking: 1) control of undesirable microorganisms, 2) denaturation of browning enzymes, and 3) an antioxidant. It is important to regularly monitor your SO_2 concentrations immediately after addition of SO_2 following fermentation. Sulfur dioxide in wine occurs in two forms, bound and free with their sum equaling the total SO_2 concentration. Generally we must be able to maintain between 20 to 40 parts per million "free" SO_2 post fermentation to produce quality sound wines. Since free SO_2 binds wine substances such as aldehydes, anthocyanins, proteins and aldo-sugars, we need to monitor our free SO_2 concentration regularly through the life of the wine. We also need to be aware that the maximum amount of total SO_2 permissible in wines made in the United States; 350 ppm. There are several methods available for testing free, bound and total SO_2 in wines. Measurement of free SO_2 with a "Titrets" kit would be recommend for only a very rough estimate of SO_2 levels. This may be utilized for quick SO_2 estimations of tanks and barrels. The Ripper method is arguably the most common procedure used in many wineries today for SO_2 determination. The Ripper method is a redox titration that is more accurate then the "Titrets" kit. There are some limitations however in accuracy with this method. 1) Certain compounds mostly in red wine can reduce iodine. 2) Detection of end points in red wine can be difficult. 3) Volatilization of SO_2 can occur during titration. 4) This procedure cannot be performed on wines with sorbic acid addition. With these limitations in mind the aeration-oxidation procedure is highly recommended for precise results.

Ethanol Content: Most table wines have an alcohol content of 10-14% by volume. A wine with to low of alcohol content may have a thin character and will be more susceptible to microbial spoilage then wines with a greater alcohol content. The other end of the spectrum includes wines with to high of an alcohol content that provide a delicate wine with a "hot" sensory evaluation. The accurate concentration of alcohol must be known also to abide by federal and state regulations for alcohol concentrations and label laws. The ebulliometric method for alcohol determination is the most recommended method for the wine industry. This method is based on the boiling point of a mixture of ethanol and water. Ethanol will lower the boiling point of water. As the ethanol concentration increases, the boiling point of the aqueous solution will lower. This method also has some limitations. Certain compounds such as sugars can influence the boiling point of a wine. Wines with higher sugar concentrations need to be diluted with water below 2% as to yield a boiling point of 96°C to 100°C. Therefore the result must be multiplied by the dilution factor to give the correct result. This dilution factor is questioned as to its integrity since you are multiplying the relative error back into the equation. It should be noted that wines analyzed for alcohol content with higher then 2% residual sugar concentration by the ebulliometer approximates that of the actual alcohol content

Protein Stability: Precipitation of protein may cause deposits to form in white wines. Protein precipitation does not appear in red wines due to the natural high tannin concentration removing protein during the vilification process. There are several factors that cause the precipitation of proteins such as heat, shaking, heavy metals and ultraviolet light. The most common method for obtaining protein stable wines is to fine with bentonite. A simple method for the determination of protein stability is to expose a measured amount of wine to elevated temperatures for a specified amount of time and observe for formation of a haze.

Tartrate Stability: Tartaric acid and its salts, potassium bitartrate and calcium tartrate are naturally occurring in grape juice and wine. Unless potassium bitartrate is removed during the wine making process, the formation of a crystalline deposit will form in the bottled wines. Although these deposits are not considered spoilage, many consumers consider them a major defect. The two most common methods of tartrate removal are cold stabilization and ion exchange. One of the most common procedures for estimating tartrate stability is by the cold/freeze tests. This procedure subjects a known amount of sample to a reduced temperature for a specified period of time. The absence of a crystal formation would indicate the wine being tartrate stable.

Malolactic Fermentation: The bacterial conversion of malic acid to lactic acid and carbon dioxide in wine is termed malolactic fermentation. This bacterial fermentation is caused by a certain lactic acid bacteria and usually occurs at the end or just after alcoholic fermentation. There are many factors that influence malolactic fermentation such as bacterial strain, temperature, aeration, alcohol, pH, sulfur dioxide and amount of inoculum. One of the main effects of malolactic fermentation is with the increase in pH and the decrease in titratable acidity. Therefore wines having a relatively low pH and high acidity may benefit from a properly induced malolactic fermentation. Depending on the chemical conditions and winemaking style it is important to be able to monitor the process of malolactic fermentation. The simplest and most common procedure for monitoring malolactic fermentation is by paper chromatography. Malolactic fermentation can be confirmed with the absence of a malic acid spot along with the formation of a lactic acid spot on the finished chromatogram.

Volatile Acidity: Measuring the volatile acidity will give a good indication of wine spoilage. A wine with a high volatile acidity is due to spoilage organisms in and their production of acetic acid and ethyl acetate. It is the production of acetic acid and ethyl acetate that gives us a sharp "vinegar" nose. Formation of volatile acidity may be influenced by several factors such as pH, available nitrogen, fermentation temperatures, duration of fermentation, oxidative conditions and surface area. The federal law limits the maximum amount of volatile acidity in both red and white wines. The legal limit for white wines is .12% along with .14% for red wines Therefore it is essential to monitor the volatile acidity. Since acetic acid is a "fixed" acid, it is essential to analyze the concentration of acetic acid with a distillation method. This is determined by passing a current of steam through the wine sample then collecting the distillate. The distillate is titrated with a standardized sodium hydroxide solution to a phenolphthalein endpoint.

The process of producing a quality wine must not rely on chemical evaluation alone. Sensory evaluation plays a critical role in wine processing. Through sensory evaluation a winemaker can tell if a wine has an "off" color, odor, flavor profile or pleasing to the nose and palate. It is important for the winemaker to have numerous sensory evaluations of the wine sample to draw a non-biased decision based on the wines quality as a varietal. Therefore, it is essential to have a separate sensory evaluation area free from any distractions and odors. The sensory lab is best separated from the wine lab to reduce chemical smells that will interfere with the sensory evaluation. The counters and walls of the sensory evaluation room should be white in color with plenty of light from incandescent or natural lighting. Fluorescent lighting will tend to create brown hues in red wines. Sensory evaluation is more convenient to have a sink located in the room.

SIZE

Make sure that you have enough space for your laboratory routine analysis.

Include proper amount of storage space on shelves, in cabinets and drawers for equipment, glassware and chemicals.

The laboratory should be large enough to accommodate several people at once. (Size recommendation being no smaller than 11' wide x 16' long.)

Include room for future expansion

LOCATION

Laboratory should be centrally located between crushing/pressing pad, fermentation, cold storage and bottling areas if possible.

The Laboratory should be enclosed with a separate intake and exhaust vent.

The sensory lab should be located separately from the wine lab in a location free of disturbances and odors.

Include plans for laboratory to be located in relation to utilities: water, natural gas, heating and cooling.

LABORATORY EQUIPMENT

A. See attachment listing the essential equipment

Store chemicals according to the specific manufacturer directions that are typically on the label.
Keep all acids, bases, solvents and oxidizers in their own designated area separate from each other and in enclosed cabinets approved for that use.
Label all incoming chemicals with receiving date and initials.

See attached list of laboratory analytical chemicals.

ORGANIZATION

A. Laboratory

1. Design specific areas for each analytical procedure. It is essential to have laboratory equipment ready to use at all times.
2. Procedures requiring gas, water, vacuum or a sink should be located close to the source.
3. The wine lab should be equipped with a double stainless steel sink, refrigerator, and oven or incubator.
4. Label all drawers, cabinets, shelves, etc. with the contents they contain for quicker access.
5. Have laboratory analytical procedures written up and accessible in the lab in the event the laboratory technician is not available to run samples.

B. Paperwork

1. It is extremely important to keep precise and organized records of wine analysis. This will enable you to trace your analytical data for any given sample back to the specific date when the procedure was performed. There should be separate data books for must analysis, fermentation analysis and post fermentation analysis.
2. Keep a logbook with the standardization of titration chemicals. This will include their concentration and date of standardization.
3. Keep all laboratory equipment and chemical purchases listed in a file for future reference.

C. Personnel

1. Appoint a laboratory supervisor that is in charge of all laboratory analysis, procedures and purchases.

RECOMMENDED WINE LABORATORY EQUIPMENT

EQUIPMENT	UNITS	EST. UNIT COST		EST. COST	QUANTITY
Beakers	12-50 mls.	$25.00		$25.00	1
Beakers	12-150 mls.	$25.00		$25.00	1
Beakers	12-250 mls.	$25.00		$25.00	1
Graduated Cylinder's	10 mls.	$7.00		$7.00	1
	25 mls.	$8.00		$8.00	1
	100 mls.	$10.00		$10.00	1
Volumetric Flask's	25 mls.	$26.00	*	$52.00	2
	100 mls.	$31.00	*	$62.00	2
	500 mls.	$45.00	*	$45.00	1
	1000 mls.	$53.00	*	$53.00	1
Burets	25 mls.	$88.00	*	$176.00	2
	50 mls.	$90.00	*	$90.00	1
Membrane Filters	.45 um	$58.00	*	$58.00	100/pk
Funnels	****	****			****
Separatory Funnels	500 mls.	$50.00	*	$50.00	1
Repipetters	10 mls.	$98.00		$98.00	1
Acid Dilutor	10. mls.	$420.00		$420.00	1
Repeater Pipet	100 mls.	$64.00	*	$64.00	1
Pastuer Pipets	250/pk.	$12.00		$12.00	1
Rubber Bulbs	24/pk.	$15.00	*	$15.00	1
Pipet Pump	10 mls.	$8.00		$8.00	1
	25 mls.	$11.00		$11.00	
Serological Pipets	5 mls. 12/cs.	$46.00		$46.00	1
	10 mls. 12/cs.	$53.00		$53.00	1
	25 mls. 12/cs.	$90.00		$90.00	1
Digital Scale	****	****		****	1
Lighted Stirplate	****	$370.00		$370.00	1
Stirring Magnets	Various	$2.00		$10.00	5
pH Meter	****	$500.00		$500.00	1
pH Meter Stand	****	$80.00	*	$80.00	1
Aeration/Oxidation	Free and Total	$250.00	*	$250.00	1
Ebulliometer	****	$560.00		$560.00	1
Cash Still	****	$725.00		$725.00	1
Brix Hydrometers	-5 °to 5°	$25.00	*	$25.00	1
	-0° to 10°	$25.00	*	$25.00	1
	10° to 20°	$25.00	*	$25.00	1
Fermentation Tubes	****	****		****	5
Thermometer	-20°C to 150° C	$20.00	*	$20.00	1
Hot Plate	****	$200.00	*	$200.00	1
Safety Glasses	****	$8.00		$16.00	2
Safety Gloves	100/pk.	$22.00		$22.00	1
Est. Total				$4,256.00	

*Indicates non-discount prices

RECOMMENDED WINE LABORATORY CHEMICALS

CHEMICALS	CONC.	UNITS	EST. COST		QUANTITY
Hydrochloric Acid	.1N	1L	$8.00		1
Sulfuric Acid	1.0N	1L	$20.00	*	1
Phosphoric Acid	85%	1L	$56.00	*	1
Sodium Hydroxide	.01N	1L	$25.00	*	
	.1N	4L	$36.00	*	1
	1N	4L	$38.00	*	1
Ethyl Alcohol	95%	4L	$60.00	*	1
Sodium Thiosulfate	.025N	1L	$8.00		1
Methyl Red	****	10.0 g.	$11.00		1
Phenolohthalein	****	100.0 g.	$15.00		1
Starch Soluble	****	100.0 g.	$12.00		1
S02 Indicator	****	1 oz.	$8.00		1
pH Buffer	pH 4.00	500.0 mls.	$5.00		1
	pH 7.00	500.0 mls.	$5.00		1
Storage Solution	****	1.0 Liter	$22.00	*	1
Potassium Iodide	Granular	500.0 g.	$40.00		1
Iodine	Flakes	100 g.	$25.00		1
Iodine	.1N	1L	$28.00	*	1
Sodium Bicarbonate	****	500.0 g.	$23.00	*	1
Hydrogen Peroxide	30%	100 mls.	$30.00	*	1
Chromatography Paper	#1	30 Sheets	$15.00		1
Malolactic Solvent	****	32.0 oz	$48.00		1
Gold Coast Solution	#1	32.0 oz.	$10.00		1
	#2	32.0 oz.	$20.00		1
	#3	32.0 oz.	$32.00		1
	#4	32.0 oz.	$10.00		1
	#5	32.0 oz.	$10.00		1
	#6	32.0 oz.	$15.00		1
Est. Total			$635.00		

*Indicates non-discsount prices

YEAST INOCULATION — FACTS ABOUT PURE WINE YEAST CULTURES

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Yeasts compose a large group of single cell organisms. The small group of yeasts that interest us on a winemaking basis are of the genera *Saccharomyces*; only a certain species of *Saccharomyces* are used. The most common species used is *Saccharomyces cerevisiae*. Among this specific species there are two common races frequently used. These races include *cerevisiae* and *bayanus*. There are many strains of these yeast. The strain name (such as Montrachet) typically designates the area from which the yeast was obtained or what it is used for (1).

Wine yeasts can be obtained from commercial laboratories in several different forms. The first form and most common for new and smaller wineries would consist of dry yeast strains. Dry yeast strains contain active dry wine yeast in which you rehydrate and add directly to the must/juice to be fermented.

Liquid yeast strains are typically intended for making up starter cultures. Agar slants are isolate strains that are used in making up starter cultures. In this paper we will focus on the use of active dry yeast strains in must fermentation.

When looking into must fermentation, we can concentrate on several terms that are commonly used in describing yeast fermentation. First there are the natural or wild yeast that consist of naturally occurring strains on the grapes and winery equipment. These strains are responsible for the natural innoculum of must. Initial fermentation is started by low alcohol tolerant yeast such as *Hanseniaspora guillermondi, Kloeckera epiculata,* and *Candida* species. This is followed by the more alcohol tolerant *Saccharomyces* yeasts. The term mixed culture refers to the inoculation of must with an active pure cultured wine yeast producing a mixed culture in which the selected strain predominates (2). The use of SO_2 addition to the fresh must will retard the growth or propagation of the natural or wild yeast so the selected added strain will predominate. There are many advantages that are noted of fermenting must with a pure cultured yeast strain instead of using a natural or wild fermentation. Some of the major advantages of inoculation with pure cultured yeast include a higher alcohol tolerance, faster fermentation rates, completeness of fermentation, higher degree of flocculation, sulfur dioxide tolerance and less hydrogen sulfide production (3). It is important to note that there are differences within pure cultured strains. Therefore, a winemaker must decide on a strain based on the variety being fermented, conditions of the grapes, chemical conditions of the must and cellar fermentation conditions.

Proper rehydration of active dry wine yeast is critical in obtaining optimum yeast viability. It is important to rehydrate the selected yeast in water rather than juice. The temperature of the water is critical during rehydration. Dissolve the yeast in 40°C (105°F) water at an addition rate

of 1 lbs/1 gal. (1 kg/2 gal). Upon light initial stirring, the yeast should be left undisturbed to rehydrate for 15-20 minutes. After the appropriate rehydration period, mix the yeast suspension and add to the must or juice to be fermented. Assuming an active dry wine yeast cell concentration of 20×10^9 cells/gm, an inoculation rate of 1-2 lbs/1000 gal will propagate up to 5×10^6 yeast/ml or 5 million cells/ml (Kraus, K.J. 1981).

There are several key factors influencing proper yeast growth such as yeast nutrients, temperature, insoluble solids and aeration. Yeast nutrients are one of the most important factors in determining successful fermentations. Nutrient additives high in assimilable amino acids (amino acids and ammonia) are essential for proper yeast growth aiding in completion of fermentation and optimum fermentation rates. It is recommended to make your nutrient additions on the minimal amount required based on the must assimilable amino acids analysis to achieve complete fermentation and optimum rates. A standard minimal amount of yeast assimable nitrogen needed for complete fermentation of a dry white table wine is frequently given as 140-160 mg/liter. A target recommendation of 200-400 mg/L should be sufficient based on variety (4). It is also helpful in identifying certain risk factors for nutrient addition. 1) White musts tend to be at higher risk than red musts. 2) Varieties that have been subject to diseases such as phylloxera, bunch rot and powdery mildew. 3) Vineyards with soil of very low fertility. 4) Fermentation of varieties with a history of stuck or sluggish fermentations. 5) High Brix juices or musts (over 24° Brix) (5). Adding too much nutrient on the other hand may develop a salty taste among other off flavors and aromas. Currently the BATF limit for ammonium phosphate addition to must is 8 lbs/1000 gallons.

Temperature is another important factor influencing proper yeast growth. Optimum temperature speeds yeast growth and velocity of fermentation. OARDC recommended fermentation temperatures of most white musts would range from 10°C (50°F) to 17°C (63°F). Most red musts would range from 30°C (86°F) to 35°C (95°F).

A third critical factor in influencing proper yeast growth is the level of insoluble solids. Insoluble solids are critical for white must attachment points fermented at low temperatures. Must that are properly racked or centrifuged will have enough insoluble solids for yeast attachment points during fermentation Musts that have not been properly racked or centrifuged will have higher insoluble solid levels reading will tend to produce a non-varietal wine with some off flavors. Therefore, to create a clean, sound, fruity varietal white wine, it is important to start with clean must/juice and rack or centrifuge properly (Singleton, V.L., et al., 1975).

If a stuck or sluggish fermentation is suspected, aeration may be helpful in finishing the fermentation. After checking the fermenting must temperature and adjusting if necessary, aeration will enable the yeast to utilize Proline as a substrate in the development of enough cells to finish fermentation (Ough, C.S., 1992).

Included in the list below are just a few of the acceptable pure cultured active dry wine yeasts that we would recommend at the OARDC.

❖White Wine	Epernay 2
❖White Wine	OA 23
❖White Wine & some red varieties	Prise DeMousse (EC118)
❖Red Wine	D 254
❖Red Wine	RC 212

The most important factor to keep in mind is the fact that wine yeast are not microscopic miracle workers. If you do not start with grapes in good condition with the proper harvest parameters, the type of yeast you use will not make much difference.

LITERATURE CITED

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PRINCIPLES OF WINE STABILIZATION

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SULFUR DIOXIDE

History

Greeks and Romans knew about sulfur, but the main uses of this chemical were not a part of their grape growing and winemaking practices. In the 14th century, many differed in their opinion on the suitability and usefulness of sulfur.

Importance

1. Advantages: Sulfur dioxide in solution is unique, because it has both antimicrobial and antioxidative properties.

   a. As an antioxidant, sulfur dioxide protects musts and wines from browning by inhibiting enzymic and nonenzymic oxidation. Also, this chemical protects wines from oxidation by reducing the amount of available oxygen.

   b. The antiseptic activity of sulfur dioxide prevents microbial spoilage in wines. It is known that certain spoilage microorganisms such as acetic acid bacteria, lactic acid bacteria, molds, and wild yeasts are inhibited by sulfur dioxide.

   c. At certain levels, sulfur dioxide may promote a rapid and complete clarification of musts and wines.

2. Disadvantages: Although sulfur dioxide is necessary in preventing undesirable change in wines, excessive amounts may cause an incomplete fermentation, bleaching of color, and cause an objectionable, pungent odor.

Source

For a small winery operation, the most convenient method for adding sulfur dioxide is to treat musts and wines with potassium metabisulfite ($K_2S_2O_5$).

Chemistry

Since potassium metabisulfite ($K_2S_2O_5$) does not contain 100% sulfur dioxide (SO_2), it is essential to know the percentage of SO_2 in this salt.

1. Chemical reaction:

$K_2S_2O_5 + H_2O \rightarrow 2\ KOH + 2\ SO_2$

2. Molecular weight:

   Atomic wt. of K = 40
   Atomic wt. of S = 32
   Atomic wt. of O = 16

   Molecular wt. of $K_2S_2O_5$ = 222
   Molecular wt. of SO_2 = 64 x 2 = 128

3. Percentage of SO_2 in $K_2S_2O_5$:

   $$\% SO_2 \text{ in } K_2S_2O_5 = \frac{128}{222} \times 100 = 58\%$$

   or

   1 gm of $K_2S_2O_5$ = 0.58 gm of SO_2

4. Conversion: grams of SO_2 to grams of $K_2S_2O_5$:

   $$\frac{1}{0.58} = \frac{\text{wt. of } K_2S_2O_5}{\text{wt. of } SO_2}$$

   $$\frac{1.72}{} = \frac{\text{wt. of } K_2S_2O_5}{\text{wt. of } SO_2}$$

   Wt. of $K_2S_2O_5$ = 1.72 x wt. of SO_2

pH

1. Importance: Acid levels, tartaric and malic acid, significantly influence must and wine pH. This factor is important to both color and keeping quality of wines. Problems with spoilage are likely to occur as pH values increase. Another reason for improved stability as the pH is lowered , is the increased effectiveness of SO_2 as an antimicrobial agent.

2. Definition:

   a. pH refers to a numerical scale for expressing degrees of acidity or alkalinity.
   b. pH = - log [H^+ conc.]
   c. $H_2O \rightleftharpoons H^+ + OH^-$ (H^+ conc. = 10^{-7})

Reaction	gms. of H^+ per liter		Log	pH
acidic	.01	(10^{-2})	- 2	2
neutral	.0000001	(10^{-7})	- 7	7
alkaline	.00000000001	(10^{-10})	-10	10

Alcoholic Fermentation

1. Equation: For the alcoholic fermentation, the overall process can be represented by the following equation:

   1 glucose → 2 ethanol + 2 CO_2 + energy

2. By-Products: Although ethanol is the major product of this process, many minor constituents are also produced during alcoholic fermentation. In addition to their importance in wine quality (aroma and flavor), some have a high affinity to sulfur dioxide; thus, forming complexes.

Forms and pH Influence

1. Forms: When sulfur dioxide is added to musts and wines, the following reactions occur in equilibrium:

   $SO_2 + H_2O \rightleftharpoons H_2SO_3$ sulfurous (molecular)

   $H_2SO_3 \rightleftharpoons HSO_3^- + H^+$ bisulfite

   $HSO_3^- \rightleftharpoons SO_3^{=} + H^+$ sulfite

   All forms of SO_2 (molecular, bisulfite and sulfite) that are not chemically bound to other wine constituents are called "Free SO_2". The molecular form is almost entirely in the "Free" form. Furthermore, the "Free" unionized form (molecular) is the SO_2 form which prevents oxidation and spoilage.

   Those SO_2 forms that combine with other constituents are termed "Bound SO_2". "Total SO_2" refers to the amount of "Free" plus "Bound" SO_2.

2. pH Influence: The amount of each SO_2 form in musts and wines depends upon the pH value. The following data indicate that as the pH decreases, the amount of molecular SO_2 increases (more antiseptic activity).

pH	%SO_2 (molecular)	% HSO_3^-	% $SO_3^=$
3.0	6.1	93.9	0.012
3.2	3.9	96.1	0.019
3.4	2.5	97.5	0.030
3.6	1.6	98.4	0.048
3.8	1.0	98.9	0.077

Weight and Volume

1. Weight:
   1 lb = 16 ozs = 454 gms

2. Volume:
   1 gal = 3.8 liters = 3790 ml

3. Measure:
   1 gal of wine = 8.2 lbs = 132 ozs = 3723 gms
   1 gal of wine = 3.8 liters = 3790 ml
   1 gal of juice (crushed grapes) = 9.0 lbs = 144 oz

Conversions

ppm	%	mg/L	Multiplication factor
100,000	10	100,000	.1
10,000	1	10,000	.01
100	.01	100	.0001
10	.001	10	.00001

Example: 100 ppm of 1000 gallons of wine

By Volume:
100 ppm = .01%
1000 gal x .0001 (factor) = .1 gallon = 380 ml

By Weight:
1000 gal x 8.2 lbs/gal = 8,200 lbs
8200 lbs x .0001 (factor) = .82 lbs x 454 g/gal = 372.3 gms

Dosage

1. Crushed Grapes: Condition of grapes, temperature, and pH are important factors in determining the amount of SO_2 to be added to the crushed grapes or musts. In general, sound grapes without spoilage, cool, and low pH require about 50 ppm SO_2.

   a. Estimate weight of crushed grapes (9.0 lbs per gallon).
   b. Determine the ppm of SO_2 to be added to the crushed grapes.
   c. Equation:

   Wt. of $K_2S_2O_5$ = Y x Z x 1.72
   Where: Y = weight of crushed grapes
   Z = multiplication factor of desired ppm SO_2
   1.72 = Conversion factor to change SO_2 to $K_2S_2O_5$

   d. Example: for a 50 ppm SO_2 treatment, calculate the weight of $K_2S_2O_5$ to be added to 2000 lbs (ton) of crushed grapes

   Wt. of $K_2S_2O_5$ = 2000 lbs (Y) x .00005 (Z) x 1.72
   = .172 lbs = 2.8 ozs

2. Wine Storage: Immediately after alcoholic fermentation, the amount of free SO_2 is relatively low in the wines. Also during wine storage, SO_2 is constantly being lost due to such factors as oxidation and volatilization. Therefore, it is essential to treat wines with additional amounts of SO_2 at regular storage intervals. Under most conditions, maintaining 20 to 40 ppm of free SO_2 will protect wines against oxidation and spoilage.

   a. Estimate volume of wine in storage (3.8 liters per gallon).
   b. Determine the ppm (mg/liter) of SO_2 to be added to the wine.
   c. Equation:

   $$\text{Wt. of } K_2S_2O_5 = \frac{Y \times 3.8 \times 1.72 \times Z}{1000}$$

   Where: Y = Volume of wine in gallons
   3.8 = Conversion factor to change gallons to liters (L/gal)
   1.72 = Conversion factor to change SO_2 to $K_2S_2O_5$
   1000 = Conversion mg/L to gms/L

   d. Example: for a 20 ppm SO_2 treatment, calculate the weight of $K_2S_2O_5$ to be added to 500 gallons of wine.

   $$\text{Wt. of } K_2S_2O_5 = \frac{500 \times 3.8 \text{ L/gal} \times 1.72 \times 20 \text{ mg/L}}{1000}$$

   = 65.4 gms or .14 lbs or 2.3 ozs

3. Bottling: It is important to inhibit spoilage yeast and bacteria in the bottle. Therefore, winemakers always adjust the free SO_2 level of their wines at the time of bottling. In general, a molecular SO_2 level of 0.8 ppm has been reported to be an acceptable concentration for most wines. The table below offers those free SO_2 levels to obtain 0.8 ppm molecular SO_2 at various pH values.

pH	Free SO_2 to obtain 0.8 ppm molecular SO_2	pH	Free SO_2 to to obtain 0.8 ppm molecular SO_2
2.9	11	3.5	40
3.0	13	3.6	50
3.1	16	3.7	63
3.2	21	3.8	79
3.3	26	3.9	99
3.4	32	4.0	125

Source: C. Smith, Enology Briefs, Feb/March, 1982, Univ. of Calif., Davis.

BATF Consideration

The finished wine shall contain not more than 350 ppm of total sulfur dioxide.

CRISIS COMMUNICATION

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The program lists this presentation as "Crisis Management," but increasingly these days, our clients call upon us for "Crisis Prevention." You can identify a lot of the situations that have the potential to escalate into a crisis.

First, let's define a crisis. It's anything that can negatively affect an organization. We stress the word "anything" because a lot of people mistakenly think that a crisis is usually a traditional problem – a fire, an injury, or a product recall.

And while it's true that these traditional crisis situations are dangerous and you need to be prepared for them, you also need to recognize that what we'll call non-traditional crisis situations are increasingly dangerous today. These non-traditional situations can include sexual harassment, political and regulatory issues, age discrimination, an investigation or scandal, a drug issue, racial slurs, political beliefs, noise and nuisance issues, and many others.

In fact, analysis of the most prevalent business crisis situations of the 1990s shows that 23 percent were related to white collar crime, 18 percent to labor disputes, and 11 percent to mismanagement. Catastrophes represented only 9 percent of the actual crisis situations, and defects and recalls an even smaller 6 percent.

In other words, you're almost twice as likely to be hit by a mismanagement crisis as by a product recall.

So, ***the first step in effective crisis management may well be broadening your definition of what a crisis is – and how it could hit you!***

An Ounce of Prevention

How can an organization plan for a crisis? You'd be surprised how often businesses see – and ignore – the warning signs that could have saved them a lot of time, money, energy, and trouble.

Research by crisis experts has shown that 66 percent of all crisis situations can be classified as "smoldering," while only 34 percent appear suddenly.

Think about it...

> ***"Well, I knew Jack was flirting with Carol, but I didn't think she was upset – and I certainly never thought she'd file harassment charges!"***

"Gosh, I guess Mrs. Evans, our neighbor, was serious when she kept calling to warn us that she was going to call the police if we had one more problem with drunkenness on the grounds."

"Wait a minute – didn't I read that a winery in Pennsylvania had a problem with contamination with this same type of bottling line? I should have expected this!"

The point is, that according to statistics, there's a good chance that someone in your organization has seen the warning signs that could lead to a crisis. Talk to your people!

How can you identify the types of crisis situations most likely to hit you? Believe it or not, it isn't like searching for that proverbial needle in a haystack. Our firm, Lord, Sullivan & Yoder Public Relations, has developed a comprehensive Crisis Inventory Form. This form lists dozens of potential crisis situations.

Crisis Inventory Worksheet

This is a list of potential crisis situations that could affect your operation. To gauge the potential impact of these and other events, please rank the probability of each of these events.

There are also blanks to identify other crisis events that aren't listed but that you believe should be addressed.

Natural Disasters	**Probability of Occurrence**				
	High	**Medium**	**Low**	**None**	**N/A**
Brush/Forest Fire					
Flood					
Earthquake					
Hurricane/Tornado/ Windstorm					
Lightning Damage					
Severe Heat					
Severe Cold					
Soil or Shoreline Erosion					
Snow/Water Accumulation on Roof/Building					
Crop Damage					
Others:					

Winery/Restaurant Operations	Probability of Occurrence				
	High	**Medium**	**Low**	**None**	**N/A**
Localized Fire					
Major Fire					
Arson					
Explosion					
Smoke/Fumes					
Kitchen Accident					
Water Leak					
Steam Leak					
Power Outage					
Electrical System Problems					
Computer System Outages					
Off Site Information Storage/Retrieval					
Transport Accident					
Public Intoxication Incident					
Parking Lot Accident					
Material Handling Accident					
Material Storage Accident					
Material/Product Contamination					
Material/Product Spoilage					
Material/Product Exposure					
Facility Accident					
Industrial Accident					
Medical Emergencies					
Emergency Access					
Industrial Espionage					
Burglary					
Terrorism					
"Perception" Issues (Please Identify):					
Other:					

Environmental Accidents	**Probability of Occurrence**				
	High	**Medium**	**Low**	**None**	**N/A**
Release of Toxic Chemicals into Air					
Release of Toxic Chemicals into Water					
Groundwater Contamination					
Soil Contamination					
Noise Pollution					
Inbound Transport Accident					
Outbound Transport Accident					
Community Protest					
Environmental Terrorism					
Outbound Transport Theft					
Fuel Spill					
Record-Keeping Issues					
"Legacy" Issues (i.e., Employee or Community Issues from Past Practices) (Please Identify) :					
"Perception" Issues (Please Identify):					
Other:					

Environmental Liability	**Probability of Occurrence**				
	High	**Medium**	**Low**	**None**	**N/A**
Long-term Community Exposure to Toxic Chemicals					
Hazardous Waste Site (Local)					
Landfill (Remote)					
Superfund Issues					
Storage/Use of Chemicals					
Disposal of Chemical Waste					
Noise					
Product/Materials Storage Issues					
Community Protest					
Legislative/Regulatory Changes					
"Perception" Issues (Please Identify):					
Legacy Issues (Please Identify) :					
Other:					

Employee Safety & Health	Probability of Occurrence				
	High	**Medium**	**Low**	**None**	**N/A**
Major Accident					
Fatality					
Multiple Fatalities					
Availability of Rapid Medical Response					
Availability of First Aid					
Exposure to Carcinogens					
Exposure to Toxic Chemicals					
Exposure to Electric Shock					
Exposure to Extreme Heat					
Exposure to Extreme Cold					
Personal Injury Suit					
Adequacy of Insurance/H.R. Policies					
Adequacy of Safety Policy					
OSHA Issues (Please Identify):					
"Perception" Issues (Please Identify):					
Legacy Issues (Please Identify) :					
Other:					

Customer Relations	Probability of Occurrence				
	High	**Medium**	**Low**	**None**	**N/A**
Critic Review Issues					
Labeling/ATF Issues					
Loss of Major Contract					
Product Liability Suit					
Product Recall					
Product Quality Issues					
Product Pricing Issues					
Product Guarantee Issues					
Product Tampering Issues					
Product Labeling Issues					
Customer Boycott					
Customer Bankruptcy					
Customer Plant Relocation					
Sabotage					
Competitor Rumor Spreading					
"Perception" Issues (Please Identify):					
Legacy Issues (Please Identify) :					
Other:					

Supplier Relations	**Probability of Occurrence**				
	High	**Medium**	**Low**	**None**	**N/A**
Product Liability Suit					
Product Recall					
Product Quality Issues					
Product Pricing Issues					
Product Guarantee Issues					
Product Tampering Issues					
Product Labeling Issues					
Supplier Boycott					
Loss of Major Supplier					
Supplier Bankruptcy					
Supplier Plant Relocation					
"Perception" Issues (Please Identify):					
Legacy Issues (Please Identify) :					
Other:					

Social Controversies	Probability of Occurrence				
	High	**Medium**	**Low**	**None**	**N/A**
Foreign Ownership					
Foreign Parent Policies					
Foreign Country Issues					
"Cause" Protesters (Please Identify):					
Legacy Issues (Please Identify) :					
"Perception" Issues (Please Identify):					
Other:					

Employee Relations	Probability of Occurrence				
	High	**Medium**	**Low**	**None**	**N/A**
Unionization					
Work Stoppage					
Strike					
Employee Protest					
Minority Employment					
Hiring Practices					
Handicapped Hiring/Access					
Unfair Labor Practices					
Sexual Harassment					
Employee Safety ● Parking Lot ● On Premises					
Sabotage					
● Insurance Issues ● Adequacy ● Domestic Partners Coverage ● AIDS Coverage/Limits ● Payment Delays ● Retiree Coverage ● Drug/Alcohol Abuse Coverage ● Cost Issues					
Layoffs					
Plant Closings					
Confidentiality Issues					
"Perception" Issues (Please Identify):					
Other:					

Management Issues	Probability of Occurrence				
	High	**Medium**	**Low**	**None**	**N/A**
Management Illness/Death					
Management Kidnapping					
Management Malfeasance					
Management Succession					
Management Perks					
Management Firing					
Management Misstatement					
Other:					

Financial	Probability of Occurrence				
	High	**Medium**	**Low**	**None**	**N/A**
Takeover Rumors					
Sale Rumors					
Plant Closing Rumors					
Merger					
Acquisition					
Currency Exchange Issues					
International Tax Issues					
Local Tax Issues					
Parent Company Financial Problems					
Sister Company Financial Problems					
Lawsuits					
Trademark or Patent Infringement					
Breach of Contract					
Antitrust Issues					
Other:					

Employee/Management Misconduct	Probability of Occurrence				
	High	**Medium**	**Low**	**None**	**N/A**
Embezzlement					
Morality Issues					
Civic Involvement					
Outside Interests					
Conflicts of Interest					
Personal/Lifestyle Issues					
Sexual Harassment					
Kickbacks					
Foreign Business Practices					
Price Fixing					
Underage Sales					
Drinking on the Job					
Suicide					
Drug Trafficking					
Other:					

Governmental Affairs	Probability of Occurrence				
	High	**Medium**	**Low**	**None**	**N/A**
Domestic Legislation/ Regulations that could impact business					
Improper Political Contributions					
Annexation					
Prohibitionist/Neo-Prohibitionist Issues					
PAC Issues					
Other:					

Sit down with employees from key departments of your organization and go over the form, line by line. Consider each of the types of crisis it lists and determine how likely this sort of situation is to arise in your operation. You'll be surprised how quickly you'll identify some patterns – and some very real threats your organization is susceptible to.

A Crisis Plan

Once you've profiled your organization's "threatscape," the next step is developing a Crisis Plan. Don't be intimidated by that term; we're not suggesting a 734-page manual that will take months to develop. Crisis plans come in all shapes and sizes, and what's important for you is to determine the information you really need. That way, when a crisis hits, you won't be running around trying to find phone numbers, equipment instructions, and medical providers.

(Just as important as developing a Crisis Plan is making sure you take twenty minutes every few months to update it. Do you still have the right phone number for police, fire, and emergency medical services? Are your contacts at ATF still correct?)

Below you'll find some recommended elements for three types of Crisis Plans for your organization: good, better, and best.

Crisis Plan Check List

Use the following check list to inventory your crisis planning materials.

√	Good Plan	Better Plan	Best Plan
	24-hour information for the following:	24-hour information for the following:	24-hour information for the following:
	Staff	Staff	Staff
	Insurance Agent	Insurance Agent	Insurance Agent
	Vendor	Vendor	Vendor
	Supplier	Supplier	Supplier
	Political Contacts	Political Contacts	Political Contacts
	Regulator Contacts	Regulator Contacts	Regulator Contacts
	Public Safety Contacts	Public Safety Contacts	Public Safety Contacts
	Legal Counsel	Legal Counsel	Legal Counsel
	PR Counsel	PR Counsel	PR Counsel
	Board-up Services	Board-up Services	Board-up Services
	Emergency Service Suppliers	Emergency Service Suppliers	Emergency Service Suppliers
	Secure computer files	Secure computer files	Secure computer files
	Facility maps	Facility maps	Facility maps
		Template press release	Template press release
		Boilerplate	Boilerplate
		Holding statement(s)	Holding statement(s)
		Q & A	Q & A
		Media fact sheet	Media fact sheet
		Security procedures	Security procedures
		Call screening procedures	Call screening procedures
		Organizational chart	Organizational chart
		Key staff biographies	Key staff biographies
		Media policy	Media policy
		Attend media training	Attend media training
		Attend crisis training	Attend crisis training
		Conduct role play scenarios	Conduct role play scenarios
		Investigate off-site crisis center locations	Investigate off-site crisis center locations
			Develop a key team in advance to manage the crisis
			Classify the crisis and develop a plan around each possibility
			And on and on…

These recommendations range from the basics – such as emergency phone numbers, backed-up computer files, and facility maps – to more complete information, including stand-by news releases and prepared Q&As for situations you've identified.

A Real Crisis

Writing a Crisis Plan is one thing, but coping with a live crisis situation is totally different. Here are some hints.

Like it or not, the crisis is going to be public. You can't run away from it. Your reputation and the reputation of your brands are at stake. Here are some do's and don'ts:

- Do find out the facts. It's tempting to start speculating, trying to minimize the damage, but if you're wrong, you'll have a hard time reestablishing your credibility.

- To "buy time" while you are gathering the facts, do prepare what's called a "Holding Statement." This is a statement you provide to outside audiences which assures them you're addressing the situation and promises to get back to them as soon as details are available.

  For example: *"We can confirm that there has been a fire at the ABC Winery, but at this time, we don't have all the details. Until we have them, we can't speculate about the situation. We're doing our best to bring it under control as soon as possible, and we'll provide additional details as quickly as they're available."*

- Do appoint one well-spoken spokesperson. The more people who speak to internal and external audiences, the more likely it is that critical details will get garbled. Make sure that everyone in the organization – especially the telephone operators and the receptionists – know that, when there's a crisis, all inquires go to that spokesperson.

- Do identify the two or three key points you want to make – and the three "dirtiest questions" you may have to address, and then prepare and rehearse your answers to them.

- Don't try to blame someone else.

- Don't ever respond to a question with a "No Comment." To the general public and the media, that's as good as an admission of guilt. Instead, learn to provide "sincere" but non-committal answers when necessary. For example, *"I can't comment on that allegation, but I can assure you that we have always maintained the highest product quality standards."*

- Do use visuals to make your point. If, for example, there's been a chemical spill, it's very effective if you can hold up a small glass and say, *'The amount of chemical actually released – less than 8 ounces – is less than the amount that would fit into this glass."* Visuals help add perspective.

- Do monitor the media. Misinformation carried on a local radio station can quickly reach national audiences.

- Do remember there are multiple audiences to address: external and internal. Employees who aren't kept in the loop can become a major source of rumors.

- Do recognize that some people will attempt to take advantage of the situation. A politician playing for votes, a union official trying to organize your workforce, a competitor trying to discredit your products, etc.

- Do show a "human touch." All too often, business people talk about costs and profits when they need to be talking about lives and jobs. Telling a reporter that, *"We looked at installing that safety equipment, but the cost was prohibitive,"* won't come across very well if there are injured employees or customers!

- Do keep the situation in perspective. Don't overreact – and don't under-react, either!

- Do realize that crisis situations can be fluid. What began as a fire can become a product quality issue if your products are exposed to smoke and water damage.

After the Crisis

Don't just assume the situation will go away. The public has become increasingly sensitive to you because of it. It's up to you to put closure to it, if necessary, by communicating what you've done to make certain it will never happen again.

And finally, once it is over, conduct a thorough post-mortem, to determine what you did well – and what you did poorly – in attempting to handle the crisis. Revise your Crisis Plan, if necessary, to reflect any needed changes.

In Summary

Recognize that a crisis has the ability to destroy your business, and that the crisis that hits you may not be a traditional fire or accident.

Prepare for the crisis by filling out a Crisis Inventory Form, to identify potential threats.

Use that list of threats to develop a Crisis Plan, and then keep that plan up to date.

Practice your response to a crisis, and practice good crisis management if you do face a situation that threatens the business.

About the Authors: Jill Fazekas and Charles Nekvasil are veteran communicators with extensive crisis management experience. Their firm – Lord, Sullivan & Yoder – is one of Central Ohio's largest full-service communications organizations.

INFLUENCE OF GRAPE MATURITY ON PINOT GRIS WINE QUALITY

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The Ohio State University/OARDC

For the past several years, OARDC has conducted a series of viticulture and enology studies on Pinot Gris. The Ohio wine industry has expressed special interest in establishing variety as a "signature grape" for our state. Presently, this grape has become a popular premium wine in Ohio. With this in mind, an investigation was initiated to determine the effect of grape maturity on Pinot Gris wine quality.

Grapes from the 1999 and 2000 season were harvested at Wooster at 3 maturity levels. These grapes were cooled overnight at 35°F, and the next day were crushed and treated with 50 ppm. After pressing, the musts were clarified with a pectic enzyme overnight at 35°F. After racking, the clear juice was ameliorated with sugar to 22°B if necessary, and acid adjusted to 0.57% with tartaric acid for the 1999 season only. Also, each juice was treated with DAP (4 g/gal.), inoculated with Wädensuill 46 and fermented at 65°F. After fermentation, wines were racked, treated with 50 ppm SO_2 and cold stabilized at 35°F. Finished wines were analyzed for pH, titratable acidity (TA), volatile acidity (VA), free SO_2 and ethanol content. Musts were also analyzed: pH, titratable acidity (TA) and Brix content. For the sensory evaluations, the 1999 wines were tested at the 2000 Ohio Grape-Wine Short Course, and the 2000 wines will be judged at the 2001 event. We regret to say that the data of the 2000 wine tastings (1999 wines) have not been statistically analyzed at the time of this publication. These results will be presented at the 2002 short course with the tasting of the 2000 wines.

The results of the must analysis at the various maturity levels for the two seasons (1999-2000) are shown in Table 1. During maturation, °Brix increased and titratable acidities decreased with a corresponding pH increase. Although pH values were acceptable (3.10-3.40) for the early- and mid-maturity levels, the last maturity produced rather high pH values (3.53 and 3.59). For the 2000 season, the titratable acidity content for each maturity level was higher than in the 1999 season. Overall, the best season for fruit maturation was in 1999, warmer and more sunlight.

Table 1.Must analysis of Pinot Gris at three maturity levels for two season, 1999-2000.

Maturity level	Harvest date	pH	Titratable[1] acidity	°Brix
1999				
Early	Sept. 7	3.23	0.57	19.0
Mid	Sept. 17	3.40	0.46	22.0
Late	Oct. 6	3.53	0.47	22.5
2000				
Early	Sept. 20	3.19	0.88	19.5
Mid	Oct. 3	3.31	0.79	21.0
Late	Oct. 24	3.59	0.73	23.3

[1]Titratable acidity as g tartaric acid per 100 ml.

For the wines, the decrease in titratable acidity and corresponding increase in pH was predictable for the maturity series (Table 2). Again, the acidities were higher in 2000 because cooler and less light conditions existed for the season. There was no real pattern for volatile acidities and alcohols in relation to maturity. For the sensory evaluations, the results of 1999 wines will be presented at the 2001 Ohio Grape-Wine Short Course along with a tasting of the 2000 wines.

Table 2.Wine analyses of Pinot Gris at three maturity levels for two season, 1999-2000.

Maturity level	pH	Titratable[1] acidity	Volatile[2] acidity	Alcohol % (v/v)
1999				
Early	3.15	0.82	0.06	13.7
Mid	3.24	0.78	0.07	13.4
Late	3.50	0.68	0.06	13.5
2000				
Early	3.27	0.92	0.07	13.2
Mid	3.36	0.83	0.08	13.7
Late	3.80	0.80	0.09	13.7

[1]Total titratable acidity as g tartaric acid per 100 mL.
[2]Volatile acidity as g acetic acid per 100 mL.

APPLICATION OF PRECISION AGRICULTURE FOR VINEYARDS

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Introduction

Information technology is playing an increasingly important role in today's agricultural production systems, regardless of operation size, type of commodities and management approach. Precision agriculture or site-specific crop management is an information-based management technique that has the potential to improve profitability and reduce the environmental impact of crop production. It also has the potential to improve the quality and nutrient content of the product.

In precision agriculture, rather than a conventional one size fits all management strategy, the field is divided into smaller zones, segments or grids and management practices are tailored to accommodate the inherent variability within certain parts of the field to optimally grow plants based on their spatial needs. Precision farming can allow regulation of a number of inputs including fertilizer and pesticide type and quantity, crop variety and plant population, cultivation practices, and irrigation and drainage decisions among many others. Each of these inputs is regulated based on response function, which must reflect site-specific conditions.

Site-specific management is an old concept but recent advances in technology, i.e., yield monitor, global positioning system (GPS), geographic information system (GIS), and Variable Rate Technology (VRT) have made it possible to apply this concept on a much larger scale. Data collection, decision-making and variable rate application are the main components of precision farming.

Grapes are an important high-value crop that can benefit from precision agriculture technology. Sugar content is a key factor that determines the quality and market value of grapes. Many factors influence both the quantity and quality of grapes including fertility management (primarily of N, P, K), variability in soil physical characteristics such as texture, compaction level, salinity etc., irrigation management, and extent of pruning. The focus of this paper is the different opportunities and technologies in precision agriculture that are currently available to grape growers.

Yield monitor for grape harvesters

The yield monitor is a basic component of precision agriculture because it provides a quantitative measure of yield variability within the field. The yield map is a vital part of decision-making and it is a good indicator of how well the fields are doing and specifically which areas of the fields are doing well or poorly.

Currently, yield monitors for conveyor-harvested crops such as potatoes, carrots, onions, tomatoes, and grapes are commercially available (HarvestMaster HM-500 (Logan, Utah)). Figure-1 shows the main components of a conveyor-harvested yield monitor. Weight or volume information is usually measured by a load or volume sensor. In conveyor-harvesters, yield is usually measured by placing weigh rollers under the existing conveyor belt (or chain) or a volume sensor which is placed on the top of the conveyor. This information is then sent to the Signal Control and Conditioning Unit (SCCU) where it is denoised, analyzed, and combined with ground speed, belt speed and tilt angle of the conveyor belt to measure the yield. Yield information is later combined with the coordinate information from GPS receiver and is sent to the field computer to be stored on the hard disk or PCMCIA card. A GIS software can then create a yield map from this data.

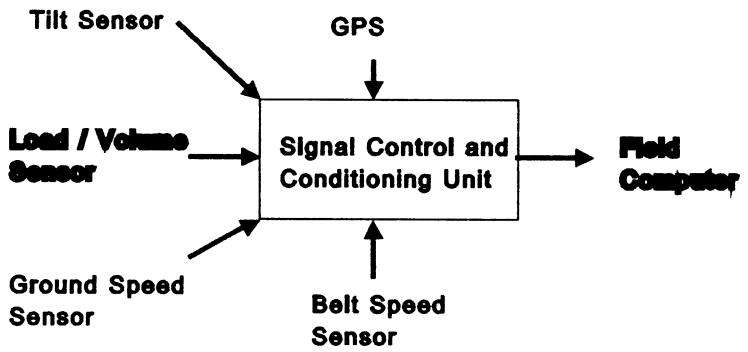

Figure-1 Main components of a conveyor-harvested yield monitor

Placing weigh rollers under the belt or chain works very well for most conveyor-harvesters for tomatoes, potatoes, onions and carrots. This system does not work well for grapes because of the relative low weight of grapes compared to the weight of the belt. When crop weight is not much greater then the weight of the belt, the stiffness of the belt creates error which is greater than the weight of the fruit. To overcome this problem, HarvestMaster has built a profile yield sensor that is placed over the conveyor and measures the volume of the grapes as they pass along the conveyor. Figure-2 shows how the profile yield sensor measures the volume. The volume information will be converted to weight using a density formula. The profile sensor consists of five ultrasonic sensors that are separated by a distance of 12 cm. The accuracy of this system is about 5 to 10 %.

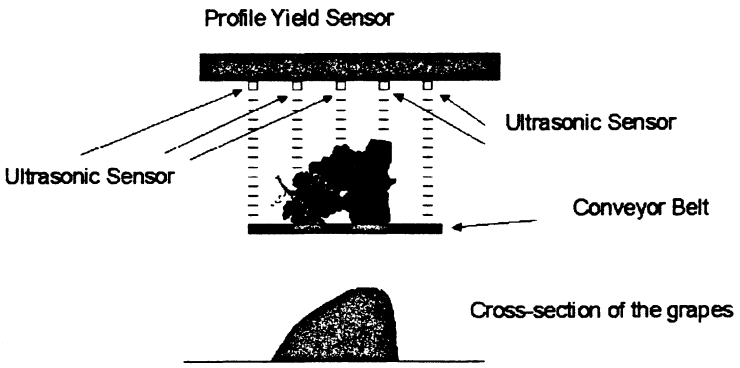

Figure-2 Principle of operation of profile sensor

Soil Sampling

Currently, soil sampling is the most effective way of determining the cause of yield variability. A GPS receiver and hand-held field computer can be used to create a field boundary map and grid points for soil sampling. Using GPS for soil sampling has the advantage that one can go to the same point for soil sampling and document the results year after year. Geo-referenced soil and plant data can be used to create different layers of information such as soil nutrient maps, soil compaction maps, soil moisture, etc. These layers of information can be used in the decision-making process. The GPS unit and hand-held computer also can be used for marking and mapping the disease, pest or weed-infected areas within the field.

Soil sampling and scouting are usually very expensive and time-consuming. Scientists are trying to develop alternatives and cost-effective ways of collecting information. Soil electrical conductivity, remote sensing, historic yield data are some sources that can provide useful information for producers.

Aerial images of the current crop can be used to determine the vegetative response to the soil as mediated by other environmental factors. Previous years' data is used to establish previous years' reproductive response to vegetation and soil conditions

Electrical Conductivity (EC)

Soil electrical conductivity is the measure of soil resistance to the flow of electric current. Soil electrical conductivity depends on the soil moisture content, soil salinity, soil texture, soil bulk density and soil temperature. In areas where soil salinity is not a main concern, many studies found similar patterns between EC maps and yield maps. In some areas, EC maps are used to select the management zones within the field. Electrical conductivity is measured using two principles; they are as follows:

1. Electromagnetic induction (EM):

This technology uses electromagnetic energy to measure the apparent conductivity of the soil. The device is composed of a transmitter and a receiver coil, usually installed 1.0 m apart on opposite ends of a non-conductive (wooden) bar. The transmitter coil is energized with an alternating current, generating a time-varying magnetic field in the earth. This magnetic field causes current to flow in the soil, and a secondary magnetic field is generated. The ratio of the secondary to the primary magnetic field is proportional to the ground conductivity of the soil (McNeill)

Variations in electromagnetic response are related to changes in the ionic concentration of the soil. Soil parameters such as moisture content, amount and type of ions in the soil water, amount and type of clay in the soil matrix are correlated to the response of the system (Doolittle et. al. 1994).

2. Direct Measurement:

A pair of coulter-electrodes are inserted into the soil. Current is applied at one electrode and the voltage drop across the two electrodes is measured. The conductivity is then computed as the ratio of current to voltage difference. The system can be stationary or mobile, and paired electrodes can be installed at different depths.
Soil EC Mapping Systems from Veris Technologies is based on this principle. The Veris unit has six coulter-electrodes and measures the EC at two depths (1 ft and 3 ft).

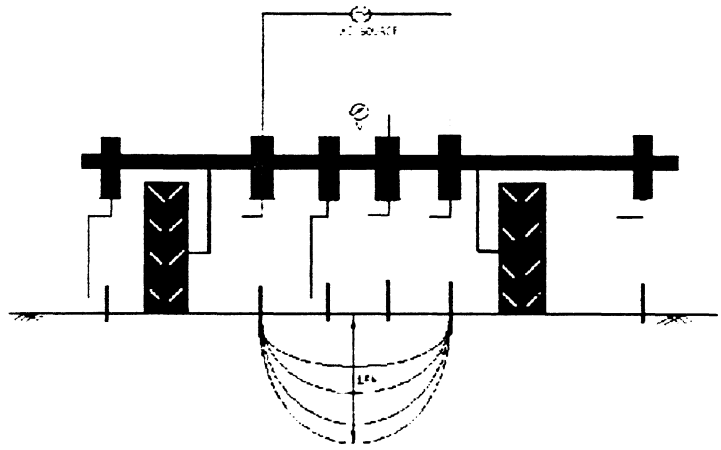

Figure-3 Direct measurement of EC (1ft)

Remote sensing

Aerial images and remote sensing data are other less expensive sources of information for producers. Hyper-spectral images contain potentially valuable information over the range of 400 to 2500 nm, which may assist in identifying soil and plant characteristics and assist in making management decisions. This information can be used for estimating disease or weed infestation problems or the existence of plant stress. For example, it is possible to calculate an index called the Normalized Deference Vegetation Index (NDVI) from these pictures. NDVI is an indicator of plant photosynthesis. Usually, a high NDVI index means high vegetation growth and low NDVI usually means low yield.

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Grape Root Borer
Expands Its Territory

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The grape root borer (GRB) is a major pest of grapes in the eastern United States. It attacks the roots of both wild and cultivated grapes of both *Vitis* and *Muscadinia*. The adult is a clearwing moth resembling a brown wasp in appearance. It has yellow to cream colored markings on its sides which encircle the abdomen.

Female Root Borer

The life cycle takes approximately 23 months of which most of it is spent as a larva or grub feeding within and under the cambium of the root tissue. This cycle is shorter in subtropical climates (Snow et al. 1990).

In Ohio, adults begin emerging in late June or early July. After mating, the adult females begin laying eggs on the trunk and vegetation near the soil surface. A single female is capable of producing up to 500 eggs. Egg hatch occurs in late August at which time the newly emerged larvae travel downward to the soil surface, burrow in and begin feeding on shallow vine roots. Approximately 22 months later the mature larvae, measuring up to 1½ inches in length begin moving upward to just below the soil surface where they pupate. Pupae wiggle their way through the final layer of soil until they are partially exposed. The adult moths then emerge, mate and lay eggs, thus, completing the life cycle.

Pupae

Past: Damaged caused by the grape root borer has resulted in enormous losses to the commercial grape industry. It has been blamed for the destruction of entire vineyards in Florida, Missouri, Pennsylvania, and the Carolinas; it is responsible for the total cessation of grape production. Its presence in the Ohio River valley is believed to have played a major roll in the demise of grape production in that region in the late 1800's, which had previously been attributed to disease. A single GRB larvae can destroy one or more of the main roots supplying the vine, resulting in an adverse affect on winter hardiness, fruit quality and yield. Two or three larvae within the root system are capable of killing a major cordon or the entire vine (All et al. 1982).

Control of this pest is difficult since it spends most of its life cycle in a subterranean habitat buried within the vines root system. Cultural methods of control have been targeted at preventing newly emerged larvae from reaching the root system. They have included the mounding of soil around the trunk and between trunks under the trellis wires or the use of polyethylene plastic under the trellis.

These practices are labor intensive, can be quite helpful. The most effective method of control in the past has been the use of insecticide applied to the soil surface during the period of adult activity, again targeting the newly hatched larvae. Unfortunately, Lorsban (chlorpyrifos) is the only insecticide labeled for control of the GRB and it is being scrutinized because it is a very commonly used pesticide around the home and yard and on the farm. Since it is an organophosphate, it is likely to be cancelled in the near future due to regulations within the Food Quality Protection Act enforced by EPA. Since this is such an important grape pest an alternative control methods need to be developed, tested and evaluated. We have been evaluating two such alternatives over the past few years, the use of pheromones to mass trap and the mating disruption technique using pheromone ties. Both of these studies were targeting the male moths in hopes of preventing or limiting their availability to females for mating; the goal being unmated females that produce infertile eggs.

GRB in sticky trap

The results of mass trapping efforts looked promising through the first few years. The GRB populations seemed to be declining from the numbers encountered at the onset. However, recently the populations have taken an up swing indicating that trapping alone doesn't appear to keep this pest in check (Fig. 1 & 2).

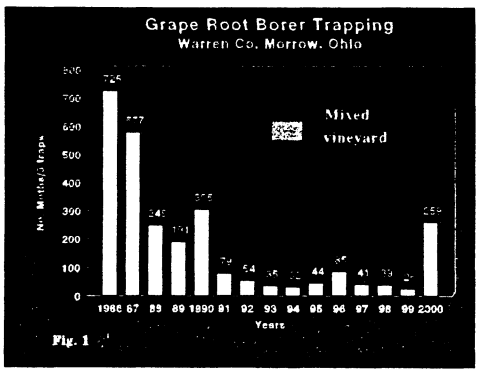


Fig. 1

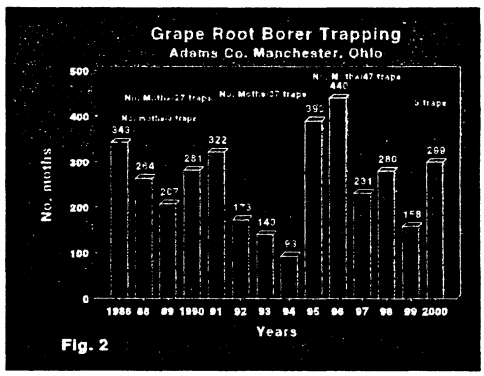
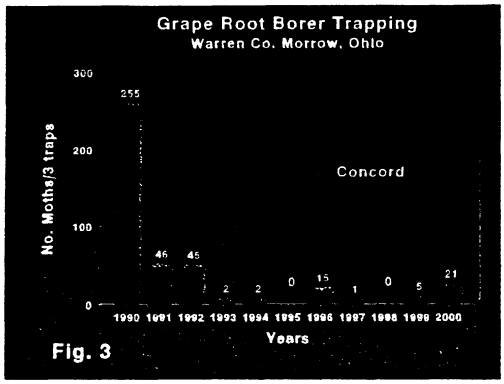
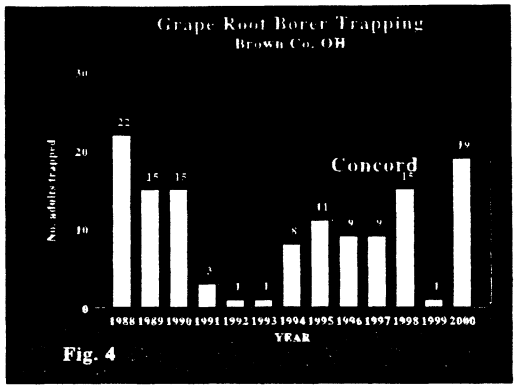


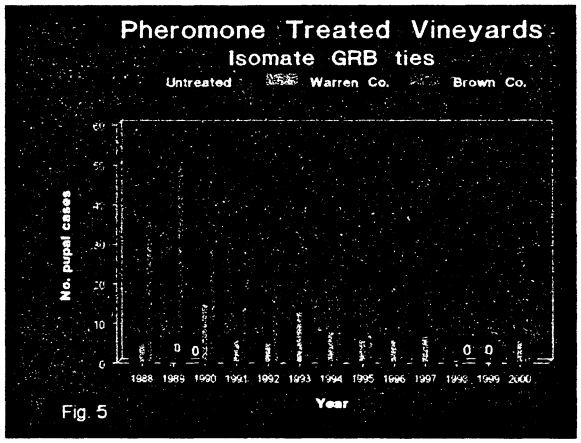
Fig. 2

Results of mating disruption studies utilizing the 'Isomate' pheromone ties have also been mixed. Traps placed external to the vineyard at one study site have shown a real decline in the number of borers captured (Fig. 3), while at the other site similar trapping has indicated a fluctuating population (Fig. 4).





Over the course of this study pupal case surveys have also been conducted within the treated vineyards. Results of these surveys have confirmed the continued emergence of adults within the Isomate treated vineyards (Fig. 5).



This would indicate that females are still attracting mates despite the blanket of pheromone or that they are flying in from external sources already mated. As previously mentioned one mated female is capable of laying up to 500 eggs so even though the pheromone may be disrupting the mating process it only takes a few mated females to produce substantial damage. These results indicate that for the first few years mating disruption is quite useful then its influence seems to diminish. These techniques for controlling this pest help but need to be augmented. The GRB pheromone is extremely attractive to male moths and is an excellent tool for monitoring for the presence and for timing emergence of the adult GRB.

Present: Growers currently have few options for control of this pest. Trapping adult males can only help, but will not provide the degree of control necessary to prevent damage from this pest. The use of herbicides to control weed growth under the vine canopy will help to provide hostile environment for newly hatched GRB larvae. This will help to create a situation in which the neonate (newly emerged) larvae

are more vulnerable to desiccation and predation. Planting cultivars with vigorous root systems will help to minimize vine stress resulting from borer feeding. Chemical control is not currently utilized enough. If we lose the grape label for chlorpyrifos (Lorsban) we currently have no approved pesticide with the toxicity and residual effect necessary to provide a barrier against newly hatched larvae. All of this comes at a time when we are seeing an increase in the cultivation of wine grapes in Ohio. French hybrids and vinifera cultivars are less vigorous than native labrusca cultivars and are more vulnerable to diseases and cold temperatures. When you add the weakening effect of borers feeding on a vines root system you have a potentially devastating combination. We know that winter hardiness, yield and juice quality will be adversely affected.

Initially we believed this pest was indigenous to southern Ohio and not present north of Interstate 70. A statewide survey conducted in 1987 and 1988 showed this to be the case. However, recent developments have indicated that it has spread into the central part of the state and as far north as Lima in northwestern Ohio. The northward expansion of the grape root borer's territory may be a result of the mild winters encountered over the past decade or due to the establishment of new vineyards in central Ohio. Traditionally the grape growing region in Ohio was the Lake Erie shoreline and the Ohio River Valley, but over the past decade, we have begun to bridge these regions with the establishment of new plantings. As a result, we may begin to see this formerly regional pest become a problem statewide. It must be remembered that we have wild grapevines over the entire state which can serve as hosts.

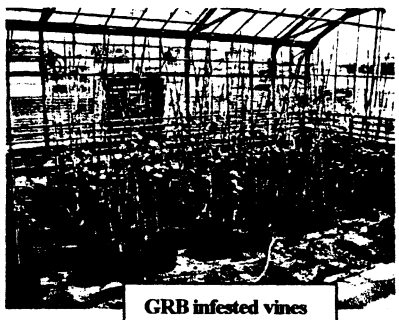
Future: Over the next couple of years we hope to conduct a new statewide survey of the grape root borer in hopes of establishing its current range and movement. As of now, we have no evidence that it has made its way into the northeastern grape belt of Geauga, Lake and Ashtabula Counties. However, this may be inevitable especially with the regional changes and climatic trends that have been taking place. We know that there is a population of GRBs in Southwest Michigan.

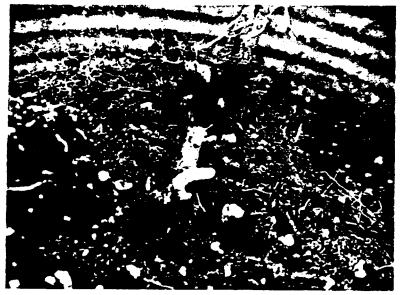
Prospects for the labeling of new pesticides for the control of the grape root borer in the immediate future are slim. The only new pesticide recently labeled for grapes is a pyrethroid called Danitol. This is the first pyrethroid pesticide labeled for grapes. Little is known about its toxicity to the grape root borer; however, it is very effective in the control of foliar pests such as the grape berry moth, Japanese beetle, phylloxera and leafhopper. Generally, pyrethroids do not have the longevity and toxicity that has been the forte of organophosphates. Newer insect growth regulators (IGRs) have promising new chemistry that may eventually become an important tool in pest control programs. Currently IGRs are targeted at lepidopterous larvae inhabiting the plant canopy and not those within the soil subsurface environment. If the technology is improved and a technique is developed to deliver these compounds to the root system of a vine, they may prove to be a very valuable tool in the future. They have already shown good promise in controlling the grape berry moth.

The use of biological control agents such as parasites, predators, and pathogens have become an area of increased interest. Over the past couple of years, we have been studying the use of Entomopathogenic nematodes to control grape pests, in particular the grape root borer. The main goal of our studies was to evaluate the susceptibility of grape root borer larvae to various new strains of entomopathogenic nematodes (Rhabditida, Steinernematodae and Heterorhabditidae), resulting in the selection of one or more strains for field trials, which may lead to a sustainable control for this pest. The susceptibility of GRB larvae to an entomopathogenic nematode known as *Steinernema carpocapsae* was demonstrated in the laboratory and field about 20 years ago (All *et al.*, 1981; Saunders & All, 1985). Although, *S. carpocapsae* caused about 80% mortality of GRB larvae in the laboratory, it had virtually no impact on the larvae in the field (All *et al.*, 1981). This failure may have been mainly due to the lack of mobility of *S. carpocapsae* in the soil profile. It is now well documented that *S. carpocapsae* uses an ambush approach to host finding (Grewal *et al.*, 1994). *S. Carpocapsae* infective juveniles ambush hosts using nictation behavior in which they stand on their tails lifting >90% of their bodies waiting for the mobile hosts to pass by. This tactic precludes infection of subterranean GRB larvae at depths of 6-12 cm by the surface adapted *S. carpocapsae*. Several new species of entomopathogenic nematodes have been discovered during the past decade (Poinar, 1990; Grewal & Georgis, 1998). It has also been discovered that certain nematode species such as *Heterorhabditis bacteriophora* and *Steinernema glaseri* use a cruising approach to host finding, and are therefore, most adapted to parasitize subterranean larvae (Kaya & Gaugler, 1993; Grewal *et al.*, 1994). We feel that the "cruiser" nematode species will be more effective than "ambush" nematodes against the subterranean GRB larvae.


Nematode emerging

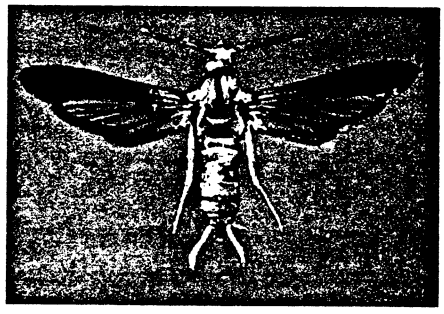
Over the past couple of years, we have screened eighteen different species/strains of entomopathogenic nematodes for virulence to the grape root borer in laboratory and greenhouse bioassays. All nematodes tested with the exception of *Steinernema bicornutum* produced some degree of infectivity. However, *Heterorhabditis* nematodes produced the highest rate of infection. Results of these studies are encouraging. A new species of *Heterohabditis* nematode that performed well under simulated field conditions in the greenhouse has been chosen for field trials beginning in the spring of 2001. Efficacy, as well as application method and timing will be addressed in these trials. We are very encouraged by the preliminary results of our work but they do not guarantee that the same results can be expected under field conditions. However, the ability of these nematodes to locate, infect and reproduce within the GRB larvae is promising. Successful proliferation of the nematode within its host


GRB infested vines



Larva on 2-year-old vine

may result in the establishment of a sustained presence in the field and provide a degree of control for this pest.



Male Grape Root Borer

The male is easily distinguished from the female as it has comb-like antennae whereas the female has no comb and the male has two tufts of hairs often called "pencils" protruding from the rear and the female has none. When using pheromone traps you will likely catch other clearwing moths along with this one. If you are not certain of the identity send the entire trap, leaving the specimens in place and we will tell you if you have Grape Root Borers or not.

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